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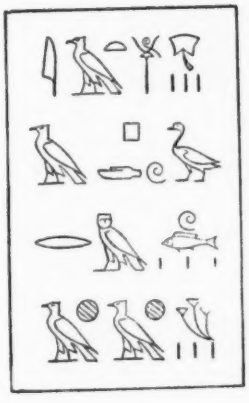

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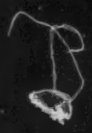

THE JOURNAL OF WILDLIFE MANAGEMENT

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POPULATION STUDIES OF WATERFOWL IN EASTERN WASHINGTON

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Prior to 1947, little was known about the summer waterfowl populations in the State of Washington. Scheffer and Hotchkiss (1945) had reported on plant-food resources and Jeffrey (1947) had conducted a nesting study in 1946 on one area in eastern Adams County.

The State of Washington Department of Game initiated a study of waterfowl breeding areas in eastern Washington in 1947 (Yocom, 1949); the authors continued population and production studies from 1948 through 1954 (Yocom and Hansen, 1948; Hansen and Yocom, 1949, 1950; Yocom, 1950, 1951b).

The purpose of this paper is to summarize our research on breeding waterfowl populations in the main production areas in Washington. Changes in populations are discussed.

The authors wish to thank J. Burton Lauckhart and Robert G. Jeffrey, State of Washington Department of Game, for reading the manuscript. All information after 1955 was collected by Robert G. Jeffrey, Wendell H. Oliver, and Ellis L. Bowhay. Other major contributors were Donald S. Galbreath, Charles W. McNeil, Stanley W. Harris, Kenneth H. Gehrman, Paul Johnsgard, and game management students Robert Salter, John Parrish, Al Canaris, Homer Ford, and William Strack.

NESTING AREAS

The many lakes, potholes and sloughs in the channeled areas (Bretz, 1928) which dissect the loess soils of the Columbia Plateau (used for the most part for the production of wheat) are the most important breeding habitats for 12 of the 18 species of ducks known to breed in Washington (Yocom, 1951b:69). Generally speaking, these channeled areas dissect the plateau from northeast to southwest. There are six main breeding areas located east of the Cascade Mountains excluding the Yakima Valley (Fig. 1), although waterfowl, especially mallards, breed throughout eastern Washington where suitable conditions prevail. The streams of the Palouse country (Yocom, 1943), which locally is considered as the loess hills of Whitman County, southern Spokane County, and adjacent country in Idaho, produce approximately one brood of mallards per mile of stream. According to accounts of early pioneers, mallards bred sparingly, if at all, in this area when it was unbroken range land.

The production of mallards and other species that nest in the mountain lakes, streams, beaver ponds and marshes of parts of Okanogan, Ferry, Stevens and Pend Oreille Counties was poorly understood until 1955. Most of this region is forested. Production estimates for this country were little better than guesses until Fred Zwickel and Stanley Guenther established transects and made detailed studies in this region in 1955.

TOPOGRAPHY AND CLIMATE

The Columbia Plateau is saucer-like. The northwest, north, and east sides are high like the rim. The lowest elevations are near Pasco (386 feet), where the annual precipitation is less than 6 inches because of the

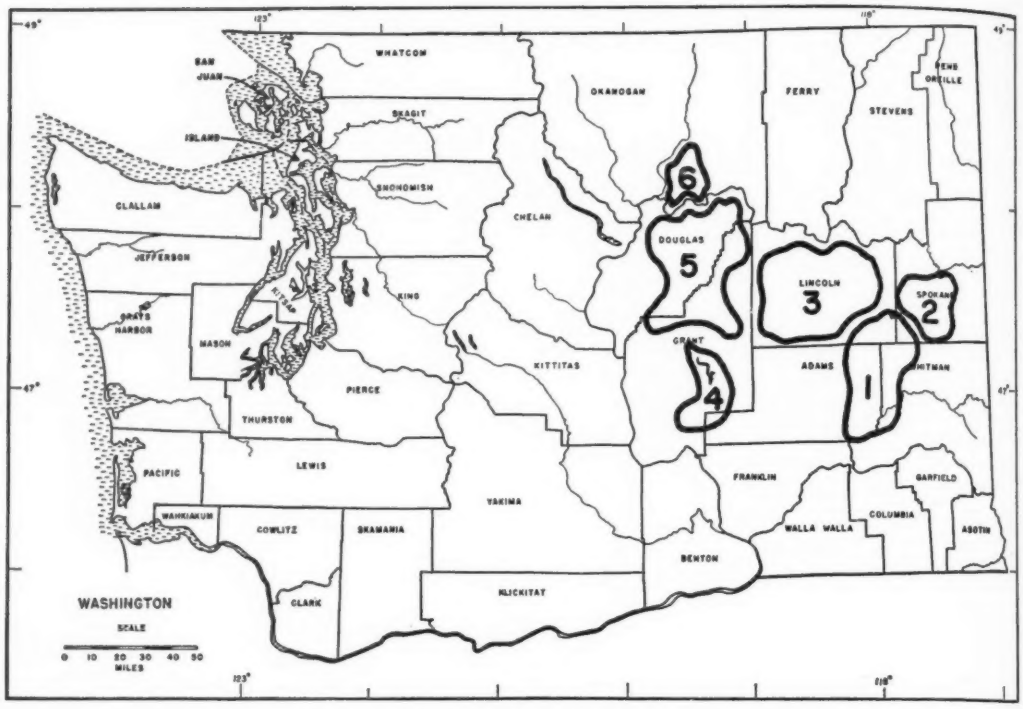

FIG. 1. Major waterfowl breeding areas in eastern Washington.

rainshadow of the high Cascades to the west. To the east and north, annual rainfall increases because of increased elevations (1,500–2,500 feet). The average annual precipitation for some of the weather stations located in the breeding areas ranges from 8.24 inches at Ruff, Grant County, to 16.35 at Cheney, Spokane County (Yocom, 1951b:13). This country is characterized by a relatively mild, modified, west coast marine climate with most of the yearly precipitation falling during the winter months. The region as a whole is known as having a summer-dry climate (Leighly, 1941). Because of the increased rainfall and underground water in glaciated areas at the heads of the channeled tracts that dissect the basaltic Columbia Plateau, small potholes, sloughs, and temporary ponds are more numerous than in the prominent, steep-walled channels farther down these drainages. Likewise there is an alkalinity gradient from north to south and from east to west. Toward the lower ends of these channels, permanent waters (very alkaline) become relatively scarce; thus, rainfall and ground water have considerable effect on the distribution of breeding species of ducks and aquatic plants.

METHODS

The major breeding areas were covered by means of car and by walking to the otherwise inaccessible marshes, potholes and lakes in the channeled scablands. All birds were recorded by areas, including detailed data on species, brood numbers, size, etc. Most observations were made in early morning and late afternoon because waterfowl are more active then. All water areas were recorded as to size and physical condition. Airplanes were used only to estimate total areas covered and total water areas present.

From 1947 to 1950, the field work started in the spring and continued until August. Yearly reports, now in the files at the Wash-

ington Department of Fish and Game, were written in August and September, and are the source of most of the data presented in this paper, which summarizes our findings on breeding populations.

VEGETATION

Daubenmire (1942) has described four basic vegetation zones for the uplands of the Columbia Plateau, and Yocom (1951b: 53–64) has described the breeding areas referred to in this paper.

Aquatic plants that are a source of food and cover for waterfowl have been determined and distribution maps for each have been made by Yocom (1951b:177–248). Marked vegetational changes occur throughout the breeding areas because of: (1) alkalinity, (2) depth of bodies of water, (3) permanence of water, (4) and possibly soil type and depth.

In the lakes and marshes in the conifer zone, which includes Area 2, the major cover plants are: yellow spatterdock (*Nuphar polysepalum*), viscid bulrush (*Scirpus acutus*), cattail (*Typha latifolia*), bur reeds (*Sparganium multipedunculatum* and *S. eurycarpum*), mare's-tail (*Hippuris vulgaris*), creeping spike rush (*Eleocharis macrostachya*), baltic rush (*Juncus balticus*), and beaked sedge (*Carex rostrata*) which forms large sedge meadows about many of the lakes in the mountainous northeast counties. Locally other sedges are important. Some of these plants also furnish much food. Scientific names of plants are those used by Yocom (1951b).

Common submersed plants in the same zone are: coontail (*Ceratophyllum demersum*), bladderwort (*Utricularia vulgaris*), water milfoils (*Myriophyllum exalbescens* and *M. verticillatum*), *Chara* sp., white water crowfoot (*Ranunculus aquatilis*), water shield (*Brasenia schreberi*), smartweeds (*Polygonum natans* and *P. coccineum*), large leafed pondweed (*Potamogeton amplifolius*), variable pondweed (*P. gramineus*), floating leaf pondweed (*P. natans*), and sago pondweed (*P. pectinatus*). Most of these plants are present in the lakes and marshes of Area 2 (Fig. 1).

The bodies of water in Areas 1, 3, 4, 5 and 6, which are in prairie zones, lack many of these plants, especially in the more alkaline lakes in the lower part of the channels. Here other plants take their places.

The most important cover plants in the prairie zones are: viscid bulrush, American three-square (*Scirpus americanus*), and Nevada bulrush (*S. nevadensis*), in Areas 4 and 5; common reed (*Phragmites communis*), mostly in Areas 4 and 5; baltic rush, and giant wild rye (*Elymus cinereus*), which grows to the water's edge in many places; creeping spike rush, and water plantain (*Alisma gramineum* and *A. plantago-aquatica*). Sago pondweed and widgeon grass (*Ruppia maritima*) are the most important food sources in many of the alkaline lakes.

Many of the temporary bodies of water have very little cover although they are important brood lakes. Other permanent bodies of water often have steep shorelines; thus, little emergent vegetation grows about them. On such bodies of water more broods may be seen than on lakes with considerable viscid bulrush. Cattail is scarce in most of the channeled areas. Many of the more important brood ponds for ducks have only a narrow fringe of *Juncus balticus* or creeping spikerush growing about their shorelines. Cover in itself does not appear to to be an important factor in determining lakes used by broods. Deep, steep-walled lakes, however, are not used extensively as brood lakes by many species of ducks unless they have shallow, marshy borders present some place on the lake.

TYPES OF HABITAT USED BY NESTING SPECIES

Mallards (*Anas platyrhynchos*), pintails (*Anas acuta*), green-winged teals (*Anas carolinensis*), blue-winged teals (*Anas discors*), cinnamon teals (*Anas cyanoptera*), gadwalls (*Anas strepera*), widgeon (*Mareca americana*), shovelers (*Spatula clypeata*), redheads (*Aythya americana*) and ruddy ducks (*Oxyura jamaicensis*) were found nesting in the six breeding areas. Lesser scaups (*Aythya affinis*) were known to breed in all except Area 4; however, prefer-

ence was shown by this species for lakes and marshes that were relatively stable in water level and supported some cattail or *Scirpus* beds.

In general, pintails avoided the conifer zone, although many lakes in Area 2 are in relatively open country, such as the lakes on Turnbull National Wildlife Refuge near Cheney, Spokane County. Only one or two pintail broods were found each year on this refuge. Pintails preferred potholes and marshes in the bunchgrass prairie zones of the Columbia Plateau.

Mallards, green-winged teals, and redheads nested both in open and wooded country. Because redheads prefer to nest over water, they were restricted to permanent lakes and potholes that had emergent vegetation. This type of lake is more abundant towards the heads of the channeled areas and in the higher parts of the Columbia Plateau (east and north sides).

Some blue-winged teals, cinnamon teals, and shovelers nested in Area 2, but they were common breeders in shallow potholes and temporary marshes of all other areas. Thus the bulk of their production was in the headwaters of the scabland channels of Adams and Lincoln Counties and western Spokane and Whitman Counties, in glacial lakes and ponds on the high plateaus of northern Douglas County and southern Okanogan County, and in potholes (now destroyed by impounded water) in the sand dunes south of Moses Lake, Grant County, in Area 4 (Harris, 1954) (Johnsgard, 1956).

Because blue-winged teal and cinnamon teal broods can not be differentiated in the field, an effort was made to determine the relative importance of these two species in eastern Washington by counting males in breeding plumage. In 1948, Yocom (1951b: 26) found the two species breeding in approximately equal numbers. From 1949 to 1951 the ratio of blue-winged teals to cinnamon teals was more than 2 to 1 (Table 1). Harris (1954) found the ratio of blue-winged teals to cinnamon teals in the potholes of Grant County to be 112:100 (based on 127 birds) in 1950 and 70:100 (based on 161 birds) in 1951. His data were collected in Area 4, which is in a more arid part of the state than the other areas.

The main breeding areas for widgeon were in the shallow lakes of Lincoln, Douglas, and southern Okanogan Counties. Ruddy ducks, like the redheads, breed throughout the six areas where viscid bulrush or cattails are common. Generally, lesser scaup breed on larger bodies of water in all areas except 4. Usually they nest on shore about these lakes (Gehrman, 1951). Gadwalls appeared to be adaptable to all of the varied conditions that existed in the six areas. Unlike most species, broods of gadwalls often occurred on the larger alkaline lakes which had steep walls of basalt about them.

In Washington, most of the breeding populations of barrow's goldeneyes (*Bucephala islandica*) nest near mountain lakes and streams surrounded by conifers. An exception to this was a breeding area found on the Columbia Plateau on Lenore National Wildlife Refuge located in the Grand Coulee, Grant County. No trees occur about Lenore Lake which is extremely alkaline.

TABLE 1.—RATIO OF MALE BLUE-WINGED AND CINNAMON TEAL OBSERVED IN EASTERN WASHINGTON

Area	1949			1950			1951		
	Bw. Teal	Cinn. Teal	Ratio	Bw. Teal	Cinn. Teal	Ratio	Bw. Teal	Cinn. Teal	Ratio
1	107	38	282:100	141	89	158:100	81	45	180:100
2	16	15	107:100	25	12	208:100	25	5	500:100
3	11	8		21	8	263:100	33	17	194:100
5				43	6	716:100	98	28	350:100
6				39	13	300:100	15	14	107:100
Misc.				9	1		3	1	
Total	134	61	219:100	278	129	215:100	255	110	232:100

Basalt cliffs from 500 to 1,000 feet high rise from most of the shoreline. Goldeneyes nest in holes in these cliffs (Yocom, 1951a; Harris, *et al.*, 1954).

Canvasbacks (*Aythya valisineria*) were rare breeders in eastern Washington. The few broods found were in the prairie potholes of Lincoln, Adams and Okanogan Counties.

Ring-necked ducks (*Aythya collaris*) found breeding in the State were restricted to the high mountain lakes of northeastern Washington; one brood, however, was seen in Spokane County (Yocom, 1951a, 1951b:31).

Western harlequin ducks (*Histrionicus h. pacificus*) breed in the Cascade Mountains, northeastern Washington and in the Blue Mountains (Hudson and Yocom, 1954).

Common mergansers (*Mergus merganser americanus*) breed on mountain streams and lakes and along the Columbia and Snake Rivers; broods, however, have never been seen in the channeled areas of the Columbia Plateau.

Hooded mergansers (*Lophodytes cucullatus*) breed in the northern part of eastern Washington along streams and on lakes. They were also observed with broods at Turnbull National Wildlife Refuge.

POPULATIONS AND PRODUCTION OF RESIDENT WATERFOWL

The forested part of the State west of the Cascade Mountains normally produces from 7 to 10 percent of the Washington waterfowl. Mallards and wood ducks are the two most important breeders in that area.

The central irrigation areas, including the Yakima Valley and the newly created Columbia Basin Project, produce about 25 percent of the annual waterfowl crop. In 1955, the Yakima River Basin supported an average of 12.5 breeding waterfowl per square mile and the Columbia Basin supported 1.9 breeding waterfowl per square mile. The Columbia Basin will contribute more waterfowl in the future as the habitat improves (Jeffrey and Oliver, 1955).

During the years of this study approximately 65 percent of Washington's waterfowl were produced in eastern Washington potholes and lakes. About one brood of mallards per mile of stream was found in the 500 miles of creeks in the Palouse Hills of Whitman County (Yocom, 1951b:61).

The geological structure and the variation in rainfall of the Columbia Plateau account in part for the discontinuity of the duck breeding areas. Because of the variable conditions, grids cannot be satisfactorily established for airplane surveys. In 1950, a plane was used, however, to count bodies of water present in segments enclosed by good landmarks such as county roads, railroads and streams. In this manner it was possible to count all bodies of water and to evaluate more accurately the percentage of lakes, potholes, and sloughs inventoried in each area. This study showed that there were approximately 10,000 lakes, potholes, marshes, and semi-permanent ponds in eastern Washington (Table 2) in 1950.

In 1947 and 1948, no attempts were made to estimate the total populations of resident ducks in eastern Washington. Sufficient data on the relative breeding populations of the different species, however, were obtained (Yocom, 1951b:82–93).

In 1949 and 1950, the number of ducks of

TABLE 2.—NUMBER AND DENSITY OF POTHOLES AND LAKES IN THE WATERFOWL BREEDING AREAS, 1950

Areas	Size of Area (sq. mi.)	Number of Potholes and Lakes	
		Total	Per Square Mile
1	420	1,971	4.7
2	324	2,884	8.9
3	261	2,101	8.0
4	53	889	16.8
5	798	1,617	1.3
6	198	373	1.9
Total	2,054	9,835	4.8
Misc. areas in Okanogan Co.			
A	414	146	0.4
B	28	16	0.6
Grand Total	2,496	9,997	4.0

A = between Okanogan River and Sinlahekin.
B = north of Grand Coulee and east of Nespelem.

TABLE 3.—POPULATIONS OF RESIDENT WATERFOWL AT THE END OF THE BREEDING SEASONS IN WASHINGTON

Area	YEARS									
	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
East. Wash.	507,300	637,336	588,000	617,400	287,000	285,000	275,400	373,400	477,700	459,300
Cent. Wash.	26,400	58,672	63,062	66,910	77,500	92,500	91,500	95,100	94,500	98,400
West. Wash.	58,000	41,418	35,000	31,000	38,000	35,000	25,300	64,900	87,600	84,900
Total	591,700	737,426	686,062	715,310	402,500	412,500	392,200	533,400	659,800	642,600

each species was tabulated for each breeding area, and broods were recorded (Fig. 4). A more thorough coverage was made in Areas 4 and 5. Area 6 was first sampled in 1949.

In 1949, the authors estimated 507,300 resident waterfowl in eastern Washington at the end of the breeding season (Hansen and Yocom, 1949). This number was derived by estimating the percentage of the total population counted. (The actual number of waterfowl counted was 30,914.)

Over 708,000 birds were estimated to have been present at the end of the 1950 breeding season in eastern Washington (Hansen and Yocom, 1950). At that time this estimate was considered to be conservative, but the figure was later reduced by Hansen based on work done in 1951 (Table 3).

Waterfowl populations in eastern Washington continued to drop to approximately 275,000 birds by 1955 because of drought conditions. By 1954, only about 50 percent of the 10,000 potholes present from 1949–51 had water in them. Since 1955, conditions have changed favorably for ducks and the populations have increased (Table 3).

Mallards are known to invade quickly any water habitat created by irrigation or impoundment (Bue, *et al.*, 1952; Sowls, 1955). Because mallards are early nesters they are less affected by drought conditions late in the nesting season and so do not require stabilized water levels to assure production.

From 1951 to 1956, unfavorable water conditions in much of the eastern Washington scablands reduced the yearly production of mallards and seriously limited production of divers and late nesting dabbling ducks. Over the same period, increases in acres of irrigated lands, irrigation ditches, and numbers of marshes resulting from surplus irrigation water occurred in central Washington, providing new nesting habitat primarily for mallards (Jeffrey and Oliver, 1955). These two changes resulted in mallards increasing in numbers relative to other species. This is indicated by the number of broods recorded (Table 4). However, the total production of mallards for all of eastern Washington during this period decreased from the peak years prior to 1951.

POPULATIONS AND PRODUCTION, 1947–50

From 1947 to 1950, the authors made detailed studies on the evaluation of breeding conditions, waterfowl populations, and

TABLE 4.—BREAKDOWN OF ALL DUCK BROOD RECORDS (1948–57) TO SPECIES FREQUENCY

Species	1948–56 TOTAL		1957 TOTAL	
	Broods	Percent	Broods	Percent
Mallard	4,449	42.0	471	47.8
Pintail	443	4.2	49	5.0
Gadwall	718	6.7	42	4.3
Baldpate	823	7.7	84	8.5
Gw. teal	514	4.8	16	1.6
Bw. and cinn. teal	1,270	11.9	125	12.7
Shoveler	424	4.0	14	1.4
Wood duck	352	3.3	89	9.0
Redhead	659	6.2	31	3.1
Scaup	251	2.4	13	1.3
Goldeneye	190	1.8	13	1.3
Ruddy	430	4.0	32	3.2
Mergansers	70	0.7	2	0.2
Miscellaneous[1]	74	0.7	5	0.5
Totals	10,667		986	

[1] Harlequin, canvasback and ring-necked duck.

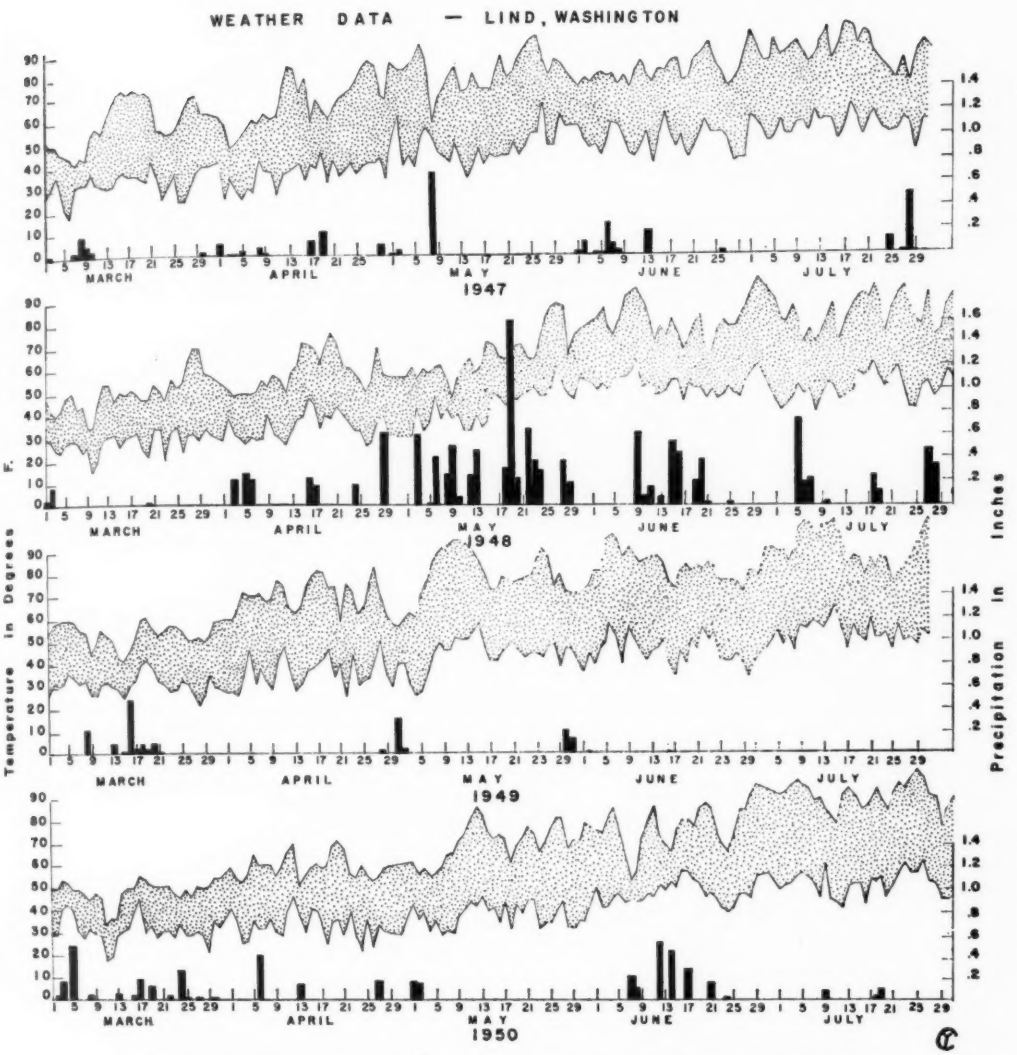

FIG. 2. Maximum and minimum temperatures and daily rainfall from March 1 to July 30 over a 4-year period at Lind, Washington.

broods produced in eastern Washington. Considerable effort was spent observing weather conditions which are known to affect time of hatching (Yocom, 1950) and production.

Weather.—Weather conditions for Lind, Washington (Fig. 2) are representative for the scabland pothole country of eastern Washington. Weather data for March, April, May, June, and July have been graphed because these are the critical months from the standpoint of waterfowl production. The years of 1947 and 1949 were somewhat similar. The year 1948 was exceptionally wet and the temperatures were below normal. The weather conditions for 1950 were also relatively wet and cold, and the area experienced considerable wind. Eastern Washington experienced a wet cycle which started in 1948 or earlier and included 1950. Over this period of time the potholes were in excellent condition for nesting waterfowl.

The spring weather conditions for 1947

and 1949 approximated those of an average year, although 1949 was slightly drier than normal from April through July. The spring months of 1948, however, varied considerably from those of 1947 and 1949. In May of 1948, there were 20 days when rain occurred (4 days when traces of rain fell, which are not shown on the graph); there were cloudy days which are not indicated in the weather records for that station (Fig. 2). June and July of 1948 also had much more rainfall and cloudiness than normal.

In 1950, an excessively cool and dry spring accompanied by winds was interrupted by several scattered rainstorms during the first 2 weeks of June. At this time the surface water conditions were more favorable than they were in June of 1949.

Weather effects on nesting.—June rains had no apparent adverse effect upon waterfowl nesting, but earlier conditions were detrimental to mallard reproduction. The cold wet spring of 1948 retarded the mallard production somewhat, but not as noticeably as the relatively dry, cold, windy spring of 1950. In 1950, range conditions were very poor and we assume that female mallards on the breeding grounds could not find suitable nesting habitat. Field observations showed that they attempted to nest, but after the first clutch of eggs was destroyed, they failed to renest again in any great numbers. This was indicated by relatively large flocks of female mallards congregated on the marshes throughout the channel scablands during the early spring months when they should have been nesting.

Fig. 3 shows that the peak of hatching for mallards occurred during the third week in June 1950, whereas the peaks of hatching occurred during the third week in May of 1947, the last week in May of 1949, and the first week of June in 1948. The authors assume that renesting females accounted for the relatively large number of eggs hatched during the last week in June and the first week in July of 1950. If renesting accounts for all of these late broods, it is evident that the renesting attempts did not offset the loss from early nesting attempts during normal years. This is demonstrated graphically in Fig. 3 for the years 1947–50. In 1950, reduction in total numbers of broods produced obviously lowered the total number of ducks in eastern Washington.

TABLE 5.—SIZES OF MALLARD BROODS IN EASTERN WASHINGTON

Year	AGE CLASS I		AGE CLASS II		AGE CLASS III	
	Broods	Avg. Size	Broods	Avg. Size	Broods	Avg. Size
1948	29	7.5	37	6.3	79	5.8
1949	72	8.1	107	6.4	173	6.4
1950	91	6.5	61	5.4	75	5.5
1951	46	6.5	59	6.5	113	6.1

The average brood size of ducks according to age classification observed in 1950 was compared to those seen in 1948 and 1949. The most significant change appears in the mallards for which there was a reduction of 1.6, 1.0, and 0.9 ducks per brood in the three respective age classes, compared with data for 1949 (Table 5). This reflects the poor conditions for the early part of the nesting season for mallards and helps to account for the reduced number of this species tabulated on the breeding areas. The overall picture of brood sizes for the other species compares favorably with the season of 1949.

In 1950, roughly 35 percent fewer mallard broods were tabulated. Similarly 45 percent fewer mallard ducks, including both adults and juveniles, were counted during the same season. The difference of 10 percent between broods and total ducks counted can be accounted for, in part at least, by a decrease of 13 percent in brood size of age class *III* in 1950. Age classes of broods used in the study and by Yocom (1951b:90) are similar to those described later by Gollop and Marshall (1954).

Because of excessive rainfall in the spring of 1948, redhead ducks apparently were adversely affected by flooding; their populations did not regain their 1947 abundance during the 4 years following.

Blue-winged and/or cinnamon teals responded to the wet years of 1948, 1949, and 1950. These species arrive on the breeding

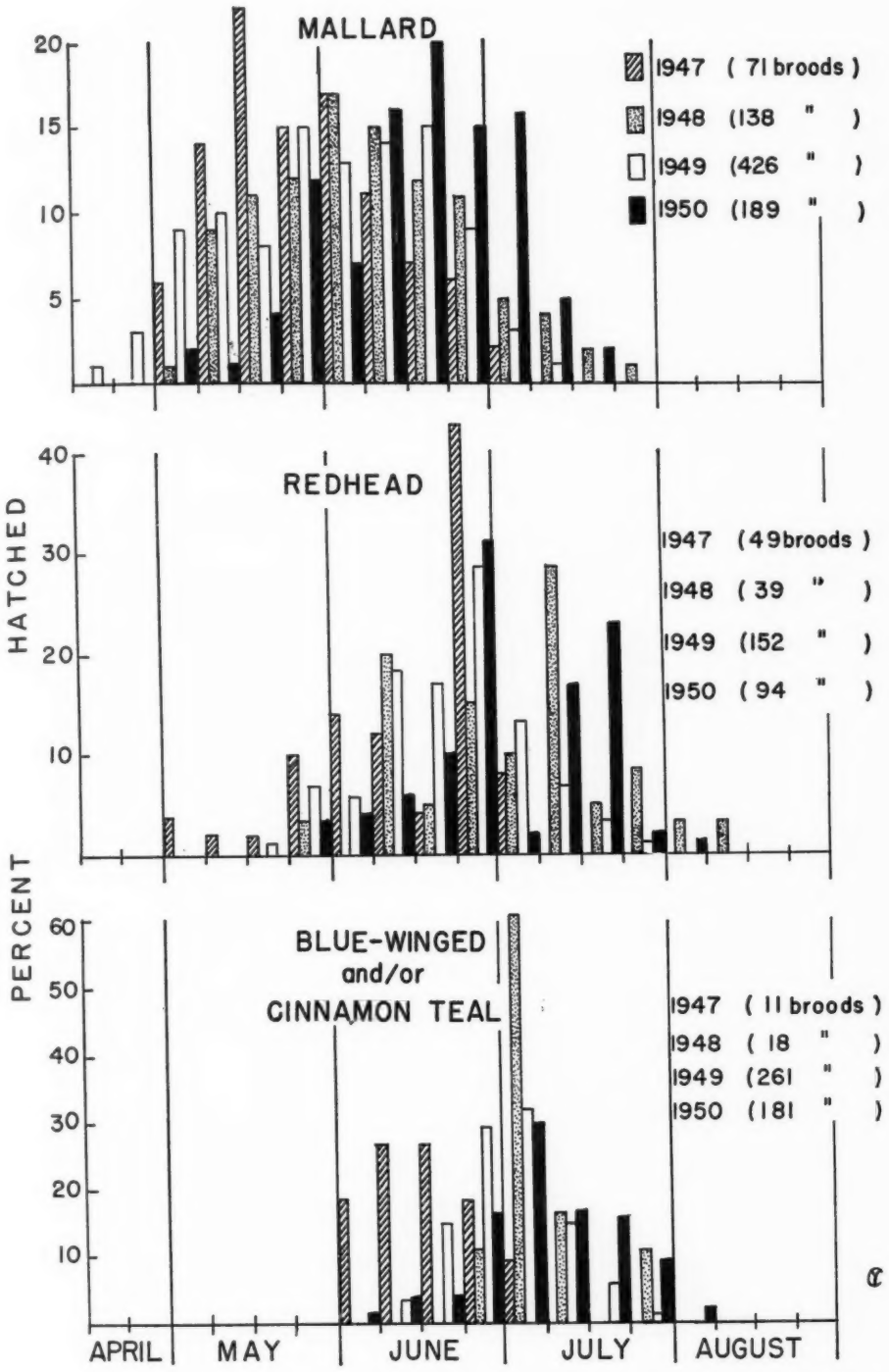

FIG. 3. Hatching dates for broods of mallards, redheads, and blue-winged and/or cinnamon teals, 1947–1950.

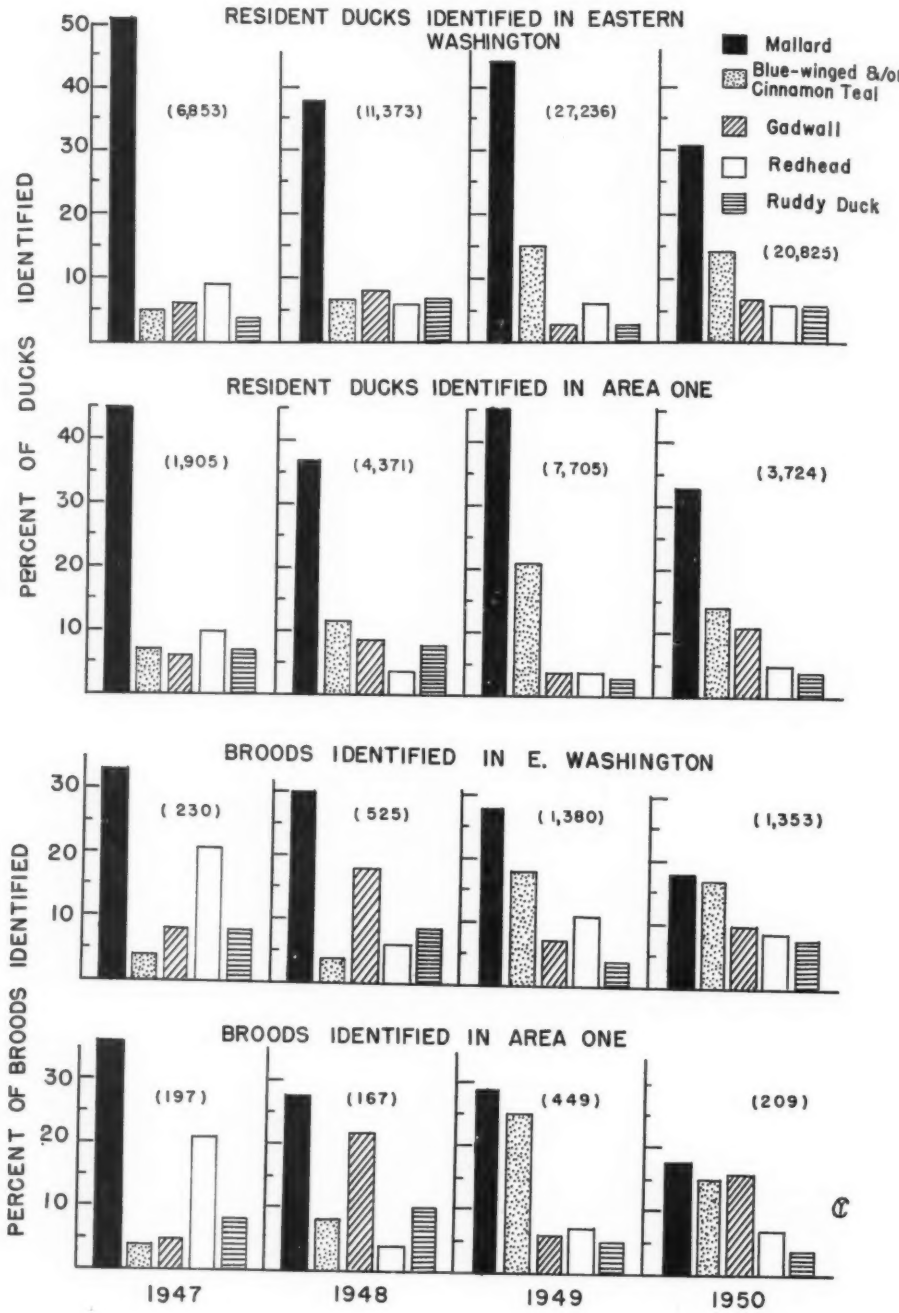

FIG. 4. The upper two graphs show the percentage of mallards, blue-winged and/or cinnamon teals, gadwalls, redheads and ruddy ducks tabulated in relationship to all ducks counted in all of eastern Washington and in Area 1. The lower graphs show the percentage of broods of these same species in relationship to total broods counted in eastern Washington and in Area 1. The total numbers of ducks and broods tabulated are in parentheses.

grounds late in the season and are not affected by the weather conditions of March and April except as they affect the overall water table. Except for 1947, the peak of hatch for blue-winged and cinnamon teals has been the first week in July. The data for the year of 1947 can be excluded because of the small sample (Fig. 3).

The key to waterfowl production includes the ecological conditions of bodies of surface water plus the weather conditions during March and April which affect those species nesting early in the season. Because of an abundance of rain during most of the summer in 1948, the lakes, potholes, and streams of eastern Washington maintained an abnormally high water level throughout the season. These conditions were followed during the winter by a record snowfall which melted gradually enough to fill with water most available depressions throughout the scablands. Thus, the waterfowl nesting season of 1949 was begun in eastern Washington under very favorable physical conditions. A high density of breeding pairs of waterfowl per unit area of habitat remained in the state following the spring migration. The absence of rain throughout the spring and summer months of 1949 created favorable nesting and hatching conditions; however, all temporary runoff ponds and most smaller potholes became dry before the first of August. Enough permanent water bodies were left for the immature ducks to move with relative safety to larger bodies of water. Thus, these favorable conditions resulted in the largest production of waterfowl for any of the years under study. Since most broods of mallards and pintails were flying before the first of July, they were not affected by the drying of temporary ponds.

BREEDING CONDITIONS SINCE 1950

In this section a summary of weather conditions and waterfowl production are presented for each year. The statements are based on data obtained by the junior author and waterfowl biologists Jeffrey, Oliver and Bowhay. These data are published in the Pacific Waterfowl Flyway Reports (1951–58).

1951.—Weather conditions were not considered detrimental to nesting waterfowl; however, a long and excessively dry spring and summer created some unfavorable water conditions before the rearing period was completed. Serious drought conditions were averted by the slow runoff which left adequate ground water for maintaining most waterfowl habitat through the rearing period. In 1950, the average brood size for mallards in age class *III* was 5.5 (Table 5), compared with the average of 6.4 young in 1949. In 1951, the size of the average class *III* mallard brood was 6.1 birds. The summer of 1949 produced a bumper waterfowl crop. There was a decrease in production in 1950. In 1951 an estimated decrease of 10 percent of the 1950 production occurred. Much of the loss in waterfowl populations during the 1950 and 1951 seasons represents a reduction of carrying capacity to the pre-1949 level. The drop in production occurred in mallards, pintails, and blue-winged and cinnamon teals, all of which seemed to respond exceptionally well to the maximum water conditions found in 1949. The summer resident population of ducks in 1951 was comparable to that of 1948. Widgeon population made a steady and marked increase in each of the three summers of 1949–51; the 1951 population almost doubled that recorded in 1948. Shovelers and green-winged teals also increased favorably in 1951.

In the spring of 1951, the upper Grand Coulee was flooded when the equalizing reservoir between Coulee Dam and Coulee City was filled (Yocom, 1951b:61). Only two or three early broods were observed in this area, which normally produces several thousands of ducks, coots, and grebes. Many nests were found flooded and downy young ducks were found dead. Many adults failed to renest and collected in large groups prior to the postnuptial molt. Rafts of nonbreeding ducks were a common sight in much of this area throughout the summer.

In 1951, the coot population increased greatly. There has been a gradual increase

since 1948, when approximately 95 waterfowl out of every 1,000 were coots. At the end of the 1951 breeding season, about 210 out of every 1,000 waterfowl were coots.

1952.—Throughout most of the major waterfowl production areas of eastern Washington, surface water conditions were favorable following the slow and gradual spring runoff. The spring and summer were excessively dry with normal temperatures. The consequent loss of some temporary ponds may have resulted in the loss of a few late nesters. In irrigated sections, water was admitted to canals earlier in 1952; this factor accounted for a more successful brood production on irrigated lands.

Of the 10 major species of ducks breeding in eastern Washington, mallards, pintails, widgeon, gadwalls, scaup and ruddy ducks increased considerably in abundance. Blue-winged, cinnamon and green-winged teals, shovelers and redheads decreased proportionately. Coots were not as successful in their reproduction as in 1951. The overall losses of some species almost offset the gains made by others, so that the final total production for all species was computed to be about 5 percent above the production in 1951. Pintails made the most notable gain, about 45 percent above their 1951 populations. Gadwalls increased 20 percent; mallards, 15 percent; widgeon and scaup, 10 percent each; and ruddy ducks made a slight gain.

The greatest loss, about 50 percent, was sustained by green-winged teal. Shovelers followed with a 35 percent loss and the blue-winged and cinnamon teal group was down 30 percent. Based upon a ratio of male teals in breeding plumage, the loss was almost entirely among blue-winged teals. Populations of redhead continued their downward trend of the past 4 years, dropping about 5 percent below the 1951 population level.

1953.—The major waterfowl producing area in the state contains about 10,000 potential scabland potholes and lakes; these suffered severely from reduced water levels following a winter of little or no snow. The number of early spring potholes was 20 percent less than in 1952; before the first of August, 60 percent of the ponds were dry. Many of the remaining ponds contained very little water and were of little value to waterfowl.

Cold, unsettled weather during the critical nesting and brooding period caused widespread nest desertion and loss of broods.

The numbers of breeding waterfowl remaining after the spring migration exceeded those recorded during the previous years under study; however, the total production of broods was much smaller. In addition to the adverse water levels, cold dry winds prevailed during April and May and caused delayed nesting and abnormal desertion among the habitually early nesting mallards and pintails. This same condition of chilly winds existed in 1950, but, in that year, loss in the production of mallards was offset by exceptionally high production among the later nesting species.

Cold, stormy weather continued during the critical nesting and breeding period from May 24 to June 9 and caused further nest desertion and loss of broods among other species. Not only were there fewer broods of all species tallied in 1953, but the average brood size was smaller in most species.

1954.—In the potholes area of north central and eastern Washington, the habitat continued to deteriorate at an alarming rate. Of the 10,000 potholes found in 1949–51, only about 50 percent contained water in the spring of 1954 and by late July so many of these had lost their water that only about 20 percent were still usable. Studies of precipitation charts from 1899 to date indicate that the water levels of 1954 were nearer to normal than during the period 1949–51, when unprecedented rain and snowfall occurred in eastern Washington.

The total breeding population of ducks remaining after the spring migration was roughly 30 percent less than in 1953; but, with more favorable weather, nesting success was increased to boost total waterfowl production slightly above that of 1953. Mal-

TABLE 6.—COMPARISON OF THE NUMBER OF POTHOLES AVAILABLE TO WATERFOWL BETWEEN MID-MAY AND MID-JULY ON ESTABLISHED TRANSECTS IN EASTERN WASHINGTON, 1952–58

Year	May Potholes	July Potholes	Percent Decline
1952	394	240	39
1953	307	220	25
1954	249	112	55
1955	264	138	47
1956	383	237	35
1957	398	247	38
1958	333	253	24

Note: The potential number of potholes, as established in 1948–50, is 428.

lards comprised 50 percent of the total production in 1953. The increase in populations of teals and divers during the wet years reduced the 6-year average of mallards below 40 percent of the total production of waterfowl. Coot populations remained near the same level to which they had dropped in 1953.

1955.—Weather during the spring quarter featured record-setting low temperature averages and above normal precipitation. Vegetative growth was retarded and waterfowl breeding activities were considerably later than normal. Late season runoff caused considerable flooding along lowland streams in central Washington and inflicted some losses on waterfowl nests during June. Water conditions in the yellow pine belt of northeastern Washington improved; an inventory of number of ponds and potholes with water showed a 10 percent increase over 1954. However, waterfowl habitat in the scablands and in north central Washington continued to decrease during the season.

1956.—Following an unusually severe winter, water conditions throughout the eastern Washington region were better than in 1955 and probably better than in any year since 1952. In the scabland potholes area, 45 percent more water areas were available to ducks during the May survey, and the July survey indicated less evaporation loss than for several years. Table 6 gives a comparison of potholes counted on established transects in eastern Washington over a period of 7 years. Improved water conditions in 1956 contributed to the largest duck crop which had been produced in Washington since 1952.

In 1957 and 1958, conditions for waterfowl nesting in Washington continued to improve and the total waterfowl production increased as shown in Table 3.

SUMMARY

These studies carried on in Washington show the importance of suitable habitat for the production of large populations of waterfowl. Some parts of the Columbia Basin area in central Washington are becoming more important for nesting waterfowl because of increased irrigation. This trend was anticipated when studies were started in the summer of 1947.

Weather conditions in March and April are important factors affecting the production of early nesting species of waterfowl for a particular year. Cold dry springs are conducive to poor production of mallards. Under these conditions, (1) many females do not renest if the first attempts fail to produce a brood; (2) many unsuccessful females congregate in flocks on the breeding grounds; (3) the peak of hatching is much later than normal; (4) the total number of broods drops; (5) the number of individuals per brood drops; and (6) the total number of mallards tabulated on the breeding grounds during the summer drops.

The total number of potholes, marshes, and lakes with water in them determines the total production of waterfowl in an area. The reduction of such bodies of water from 1950–55 caused the total population of waterfowl on the breeding grounds in Washington to drop from a high of over 700,000 to a low of less than 400,000 birds.

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BEHAVIOR OF BARREN GROUND CARIBOU ON THEIR CALVING GROUNDS[1]

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The former and present distribution, migrations, life history, and ecology of the barren ground caribou (*Rangifer arcticus*) have been described by Banfield (1954). During recent decades many facts were recorded about its biology. However, coincident with the expansion of human activity into its range, the species became so scarce that its future became doubtful; thus it soon became obvious that no permanent solution of its conservation problem could be hoped for until every aspect of the biology of the caribou, including various aspects of its behavior, had been systematically studied.

[1] Research conducted under contract with the Canadian Wildlife Service, Department of Northern Affairs and National Resources.

In the past many isolated observations have been made of the behavior of caribou, some of which were useful. However, only when data are collected in a systematic fashion and on a quantitative basis can a proper evaluation be made of the various activities observed. It was my task to go to the caribou range for this purpose, and I was therefore flown on May 22, 1958, from Yellowknife about 175 miles in a northeasterly direction to Sifton Lake, Mackenzie District, Northwest Territories. On May 28, I was transferred to Gas Cache Lake in Keewatin District, situated approximately 50 miles southwest of Beverly Lake. On June 10, I was moved once more to an area between the east shore of Beverly Lake and the Tibielik River where I remained until July 6.

The author is grateful to John P. Kelsall, in charge of caribou investigations for the Canadian Wildlife Service, for his interest in and support of this study. Thanks are also due to W. O. Pruitt, who made some critical suggestions regarding this manuscript. Edward M. Ray of the Michigan Department of Conservation, who accompanied me, helped me a great deal. To him go my most sincere thanks.

PROCEDURE

The method was to spend as much time as possible observing caribou with a minimum of disturbance, recording every meaningful activity along with the time of the observation, and the sex, age, and numbers of animals involved. Equipment included a pair of 7 × 50 binoculars, a spotting scope with 30× magnification, and two hand-operated tally counters.

The period of observation centered around calving, a portion of the caribou life cycle deliberately chosen as the most important gap in our knowledge. A limitation of the present study is that I was unable to identify individuals.

Work similar to that reported in this study has been done on other members of the deer family: on moose by Altmann (1958), Denniston (1956), and de Vos (1958); on red deer by Darling (1937); and on elk by Altmann (1952, 1956).

SOCIAL ORGANIZATION

Leadership

Although barren ground caribou are gregarious, several characteristics do not seem comparable to other Cervidae which live in herds. An absence of leadership is indicated by their indecision when changing direction or when about to swim, and by the lack of organized action among alarmed bands. Leadership at the spearhead of a moving band is changed frequently without regard to sex and age. There appear to be no highly developed social relationships between individuals, except for those between cows and their calves. Although rather definite sex and age groups exist during the spring, no leaders seem to be involved in forming these groups or in keeping them intact. Actually, these units do not seem to consist of constant numbers of individuals. Bands may join and split depending upon the movements of caribou, topographic features, and weather factors.

Band Size and Composition

The frequencies in size of bands, including bands with calves, were recorded for the period June 1 to July 5. Of 230 bands observed, bands consisting of 150 or more caribou were relatively scarce (4 percent of the total number). Those ranging in size from 2 to 5 were observed most frequently (26 percent), followed by those ranging from 6 to 10 (20 percent). Among the groups of 2 to 5 caribou, 11 groups consisted of a cow and a calf well separated from other adults. Small calving bands appeared to mingle or split freely. When a large band departed from a certain place, smaller bands generally followed.

Although most bands on the calving grounds consisted largely of pregnant females, a few were composed entirely, or almost entirely, of yearlings and barren cows. Apparently most yearlings either left the herd by choice, or were cast off by their mothers some time before the pregnant

cows reached the calving grounds. Bands of yearlings intermixed with barren cows usually arrived at the calving grounds later than pregnant females.

Evidence collected at Gas Cache Lake indicated that the bands first to arrive at the calving grounds had the highest percentage of pregnant cows. Bands examined between May 28 and 31 seemed to consist almost entirely of prime-aged, pregnant cows, while those arriving between June 8 and 11 appeared to include a high percentage of barren cows. Among 115 segregated cows observed during the latter period, 18 (16 percent) were considered barren, as suggested by the presence of small (1–3 inches) antlers in the velvet. According to Shaposhnikoff (1955), barren female reindeer shed their antlers prior to April, whereas pregnant females shed theirs after calving. In the vicinity of Beverly Lake, only 1 of 407 cows observed on June 11 and 12 had developing antlers. The first non-calving band seen here on June 15 consisted of 23 barren cows and 4 yearlings.

While a few 2- or 3-year-old bulls traveled with bands of cows ready to calve between May 31 and June 8, no older bulls were seen before June 12. Only a few bulls older than 3 years appeared. Most of them travelled singly, but some were accompanied by one or two others. A few bulls associated with bands of calving cows.

Calfless cows and yearlings were observed feeding in much greater frequency on the fringes of calving bands than were cows with calves, particularly by the end of the calving period. Cows and their calves generally remained together near the center of their band.

COW-CALF INTERRELATIONSHIPS

The interrelationships between a cow and her calf change fairly rapidly after birth and progressively lessen. I was able to carefully record a birth and subsequent developments on June 12. Birth took place 65 minutes after the first evidence of labor (a slight protrusion of part of the calf). The cow showed little special activity during parturition except for the fact that she remained bedded down for an hour while almost the entire band milled around. Only half an hour before birth she fed for several minutes while lying down. One hundred minutes following birth the cow started to graze for short periods, interrupted by short rests. The band to which the cow was attached slowly moved away during and after parturition, and she was left alone for about half an hour before she left in the direction of the departed band. She walked short distances only, followed by intervals of waiting to allow the calf to catch up.

The activities of the calf following birth indicate that calves are very precocious (Table 1). Calves made some effort to graze on the day of birth. A calf, although slow and wobbly on its feet the first day, could run remarkably well by the second day. By the third day, it generally had no difficulty keeping up with adults.

During the first 4 days after birth, a cow generally remained close to her calf and frequently licked and nuzzled it. When the mother started moving, the calf sometimes stayed behind and tried to attach itself to another cow in the same band. Of particular interest is the fact that young caribou did not show the "freezing" pattern of behavior typical of many species in the same family. There were no signs of females caching or hiding their calves.

When a calf could not run fast enough to keep up with a disturbed band, its mother usually fell behind the fleeing band to stay close to her calf. However, when closely pressed, cows left their calves. If

TABLE 1.—ACTIVITY OF A CARIBOU CALF AFTER BIRTH

Minutes After Birth	Activity of Calf
11	Gets up and drops down again. This was followed by several other efforts.
15	Stands up and remains on feet for a short while.
25	Takes a few wobbly steps.
140	Walking for 2 minutes.
180	Makes efforts to nurse.
220	Walking away with the cow.

a calf did not move away fast enough after a band was suddenly alarmed, its mother approached it with lowered head as if to induce it to flight, sometimes by making an upward movement of the head. This head movement was also made by cows in large milling bands, to draw the attention of their own calves or to fend off strange calves.

From 4 days of age onward, calves grazed progressively further from their mothers and started to run more widely within and around a band. Calves associated with each other more and more in rest, by bedding together, and in play by running after one another. They also had mock battles in which they reared up and struck at each other with their front hooves. Calves appeared to run and play more actively early in the morning and late at night than at any other time. The older a calf became, the farther it might run from its mother, e.g., a week-old calf might run as far as 100 yards.

Cows usually fended off strange calves which approached them closely. In small bands of 10 or fewer cows, in which individuals were more familiar with each other, strange calves were sometimes tolerated at close range by cows, but they were not allowed to nurse. Warding off might be done by striking with a front hoof or kicking with a hind leg. One cow was observed to lift a strange calf partly into the air with her antlers. A few times, strange calves were chased short distances by cows. When a cow was uncertain of the identity of a calf, she smelled it.

Cows generally knew where their calves were located in a large band. When feeding, a female moved around the place where the calf bedded. Sometimes a cow stopped feeding and moved directly to the calf which usually nursed. Often, when nursing was completed, the calf followed the female for a short distance. When a cow approached her calf, or when a calf was nearing its mother, both animals generally moved their ears forward and lifted their tails at the same time. This tail lifting was also observed when caribou were alerted, and when they stretched themselves after a period of bedding.

A calf desiring to nurse usually walked or ran to its mother and approached her from the side or the rear. When nursing the calf, the cow sometimes spread her hind legs slightly, or lifted one leg. On a few occasions a calf nursed with its head between the hind legs of the cow while she was walking. On the average, nursing lasted about one-half minute, but ranged from a few seconds to 3 minutes. Two-or 3-week-old calves were often so eager to nurse that they pushed their mothers several steps before the cows stood still.

ACTIVITY PATTERNS

Movements on the Calving Grounds

The forward portion of the herd arrived at the calving grounds by mid-May, and nearly all females were present by early June. As the period of parturition approached, a migratory behavior pattern was replaced gradually by a drifting movement. Although some bands appeared to be migrating until June 10, most of them had discontinued their movements in a northeasterly direction and had started to drift.

The slow, drifting, and more or less random straggling movement of a band during the calving season may be described best as "amoeboid" in nature: small sections of the band continuously make "pioneer" movements in various directions. While the bulk of the band is at rest, the animals which make these movements generally return after a while in order to stay with their band. However, when a band becomes restless it may follow a movement started by a few individuals.

Starting on June 28, caribou became increasingly restless, walking and running became more frequent, and resting periods decreased. When alarmed, bands moved long distances in contrast to only slight movements during the peak of the calving period.

Daily Activity Patterns

Despite an inclination to rest during the

darkest hours, caribou were active at all hours of the day or night. In late spring and early summer the daily activity of caribou bands seems to reach two main peaks, one each during morning and afternoon. According to Banfield (1954), "Caribou feed casually during the entire 24-hour period, but there are peaks in their feeding activity during the forenoon and evening. At other periods feeding is desultory, being interrupted by long rest periods. During mid-afternoon there is a general lessening of activity and long rest periods are taken." Harper (1955) suggests that during spring migration periods of activity are mainly from 10 to 11 a.m., from 2:30 to 5 p.m., and in the evening. An analysis of data obtained on various travelling bands during the period May 23 to June 11 suggests that peak activity takes place between 10 a.m. and 12 n., and again between 2 and 5 p.m., agreeing closely with observations by Harper (1955).

Such variables as size of bands, weather conditions, disturbances, and availability of food seemed to affect the activity of caribou bands to a greater or lesser degree. Winds over 25 m.p.h. seemed to induce bedding. On May 29 and 30, when blizzard conditions prevailed most of the day, practically all caribou were bedding down with their heads pointed away from the wind on bare patches of ground. Two standing animals, however, were facing the wind. A few animals were feeding, but soon bedded down.

After a period of adverse weather conditions, bands seemed to feed more actively than at other times. On sunny mornings and evenings, cows and calves seemed to prefer to bed down at right angles to the rays of the sun so that the body absorbed a maximum amount of sunshine.

The movement pattern of a large band was more or less pulsatory in that the rear animals moved rapidly to catch up with the band while the leading animals were resting, often passing the majority of the resting animals before settling down. While a band was active it was widely dispersed; while at rest it was rather compact.

An undisturbed large band seemed to have periods of activity and resting during the calving season. Such an "activity cycle" was observed on June 25 in a band of about 250 cows. Movement was discontinued in a particular direction and feeding was started on the spot. Subsequently, most calves started to bed down. In about 30 minutes approximately one-half, and in about 45 minutes nearly all of the adults in the band had bedded down, whereafter the band rested for about 2 hours. Then part of the band started to move suddenly, and within 15 minutes all caribou had moved away.

Even during peak activity some individuals in large bands (over 150 animals) rested. In small bands (50 or less), the activity pattern seemed to be more closely coordinated, i.e., whenever a good majority of the animals arose, the remainder usually followed.

Activity Patterns of Cows and Calves

Attempts were made in this study to compare the activity patterns of cows with those of calves. The percentages obtained on moving and feeding were lower than in reality, as it was impossible to make satisfactory counts when a band was really moving or milling around. The following method was used in obtaining cow-calf activity data: generally a small band of 20 cows or less was located, because this reduced the possibility of an obstructed field of vision by animals other than those under observation. Subsequently, two calves were selected away from the center of the band for observation by spotting scope. Usually their mothers were located soon after.

Activities of calves and their mothers in unalarmed bands are recorded in Table 2. The periods of observation of individual calves and their mothers ranged from a minimum of 10 minutes to a maximum of 96 minutes with an average of 38 minutes. Observations were made between 3:20 a.m., the earliest, and 6:50 p.m., the latest. Calf observations are grouped in age classes of less than 1 week, from 1 to 2 weeks, and from 2 to 3 weeks (based on criteria which cannot be enumerated here). For each age group the activities are expressed in minutes dur-

TABLE 2.—ACTIVITY PATTERNS OF UNALARMED CARIBOU COWS AND THEIR CALVES

Estimated Age of Calf	ACTIVITY OF CALVES DURING A PERIOD OF 100 MINUTES (IN MINUTES)				ACTIVITY OF COWS DURING 100 MINUTES OF CALF OBSERVATIONS (IN MINUTES)			
	Feeding (not nursing)	Moving (not feeding)	Bedding	Standing	Feeding	Moving (not feeding)	Bedding	Standing
Less than 1 week (293 minutes of observation, 11 calves and their mothers)	3.3	19.6	75.0	2.1	63.9	6.3	26.1	3.7
1–2 weeks (1349 minutes of observation, 33 calves and their mothers)	7.5	14.4	75.4	2.7	54.9	5.1	37.9	2.1
2–3 weeks (751 minutes of observation, 20 calves and their mothers)	14.0	20.0	61.5	4.5	55.9	14.9	23.9	5.3

ing periods of 100 minutes of observation. The tabulated data disclose the following: (1) calves bedded more than cows, the calf resting periods lasting from a few minutes to about 1½ hours; (2) cows fed on vegetation considerably more than did calves, but non-feeding calves moved about somewhat more than non-feeding cows; (3) the amount of time spent by cows and calves in standing or idling was insignificant as compared to their other activities; (4) the activity pattern of adult cows did not change significantly during the study period, but for calves feeding activity increased.

Data were collected also on the frequency and duration of suckling, the amount of playing, and the maximum distance a calf moved away from its mother. Although these data do not indicate a decrease in playing activity with an increase in age, other field observations suggested that this was the case.

PROGRESS OF CALVING

It appeared that little calving occurred in late May. Calves were born with increasing frequency from June 1 until June 12, decreasing suddenly thereafter. We saw the first calf on June 1 which was probably born on May 30, considerably later than the first date of birth (May 12) reported for Alaska by Murie (1944). The peak of calving was estimated to have occurred around June 12. The first band containing the maximum possible number of calves was seen on June 20. This band consisted of 18 adult cows with their calves, 1 barren cow, and 2 yearlings. After June 22 no recently born calves or pregnant females were observed (Table 3). No calves 1 week or less in age were observed on June 30 or July 1.

There seemed to be a difference in progress of calving among various bands. While one band was fairly well advanced in calving, another might not have produced a single calf. On June 11 one band of about 125 cows was entirely calfless, while another band of about 600 cows contained approximately 10 percent calves.

VOCALISM

During the calving season vocalism seemed to serve primarily to keep cows and calves together. Bands seemed to be particularly vocal when the animals were in a state of excitation or indecision. However, adults also snorted when suddenly alarmed. Banfield (1954) stated, "The calves bawl frequently during the first few months of their lives. Because of the bawling of calves and the low short belching grunts of the adults, there is a great deal of noise associated with a large herd.

"During early July, 1949, it was noted that

TABLE 3.—PROGRESS OF CALVING DURING THE LATTER PART OF THE CALVING SEASON

Date	Estimated			Estimated Ages of Calves	Remarks
	Cows	Calves	Calves per 100 ♀♀		
June 19	97	60	62	No calves less than 2 days old	No pregnant females?
June 20	21	18	86	7 calves 10 days old; three, 2–4 days old	1 barren female; 2 yearlings
June 21	136	51	37	One 2-day-old calf	
June 22	200	100+	50+	No 1- or 2-day-old calves	
June 25	260	150+	58	Youngest calves 4 days old	
June 28	250	150+	60+	2 calves 4 days old	
June 29	350	?	?	No calves less than 1 week old	

a significant variation in the amount of clamor of a large herd was associated with the daily activity. The peak was reached in the early morning and evening, at the height of the feeding periods. During the afternoon, when most of the caribou were resting, there was little clamour." My findings are comparable, and also indicate that vocal activity is greatest when the animals are most active. On June 25, when there was no wind, calf bawls could be heard distinctly from a distance of ½ mile.

SWIMMING

Caribou are good swimmers. Banfield (1954) mentions that calves take readily to water at a very early age, but that they cannot swim as fast as their parents. I agree that calves can swim when they are very young. There may be a short period in June when there are so many small calves in a band that the adults hesitate to cross streams and lakes. On June 17, 19, and 26, some bands attempted, but failed, to cross a river with a rather strong current. After one or more cows had taken to the water, calves hesitated to follow, thus discouraging these bands from further efforts to cross. The first record of a band swimming across a river was obtained on June 18. While swimming, each calf tried to stay close to its mother's tail.

CALF MORTALITY

In this particular study inclement weather did not appear to affect calf mortality seriously. On June 12, four dead calves were found which appeared to have succumbed during a blizzard 3 days previously. Another cause of calf mortality was found on June 13, when I surveyed a drumlin on which a calving band estimated at 600 cows had spent about 24 hours during the 2 previous days. On an area of about 25 acres, 7 dead calves were located. All of these, except one, had died during the previous 24 hours. When five of these calves were skinned and examined more closely, it was found that all had bruises, two had body punctures, one a broken skull, and another one a broken vertebral column. From all appearances, the punctures were made by antlers, and it seemed clear that all these calves died as a result of violence by adult caribou. Their age varied from 1 day to 1 week. It was possible that these calves became lost in the band, tried to attach themselves to strange females, and were violently attacked. It seemed likely that this cause of mortality was restricted to calves not more than 1 week of age as older calves are able to elude attacking cows.

REACTIONS OF CARIBOU TO DISTURBANCES

Much has been written about the stupidity of caribou in their reactions to human

beings. It appears to me that caribou are not as stupid as they are generally considered. This opinion is based upon my observation that bands usually are not readily alarmed by man unless a band consists of cows with calves; otherwise bands are easily alarmed by the presence of prowling wolves. The senses of smell, sight, and hearing seem to be reasonably well developed.

Caribou are known to be curious, and many examples of curiosity were noticed in the present study. It may be that relative unfamiliarity with human beings induces this behavior trait, which may be disadvantageous to the species in terms of survival. An old Eskimo trick to attract caribou is to arouse their curiosity, e.g., by kicking feet into the air. This was tried out once on a cow. This animal circled the observer and approached to within 50 feet.

On the whole, large bands of several hundred or more head may be approached more readily than small bands. This may be because the presence of large numbers of fellow-travelers makes each individual feel more secure. Particularly during the height of migration, individual caribou in large herds may approach human beings closely without becoming unduly alarmed.

Generally, there was little time lapse between the moment caribou were alerted and the moment they started to flee. This varied with conditions such as the size of the band, the season, the weather, and the topography of the terrain. What ordinarily happened, as I approached a band of caribou, was that one or more animals either saw or smelled me and reacted by raising their heads. This action apparently alerted other members of the band, which usually discontinued whatever activity they were engaged in and also raised their heads.

After gazing at the observer for a period varying from a few seconds to several minutes, the band usually ran off. When I was close, caribou generally stampeded in tight formation, with heads held horizontally and the ears held back. When the animals were not greatly alarmed, they ran off in a loosely formed group. Usually neither stampeding nor running lasted very long, the animals covering from 25 to 100 yards in this fashion.

A definite alarm reaction seemed to be the raising of the tail which made the white underside visible from some distance. Not all members of an alerted band raised their tails; sometimes the tail was raised by one or more individuals in a band while no obvious source of alarm was to be found.

When certain animals were greatly alarmed, they made an "excitation jump," leaping into the air with all four legs. This jump was also made by animals rejoining a band.

In this study I made an effort to determine the alerting and flushing distances of various bands under different environmental conditions, and to test the relative use of the various senses. The flushing distances ranged from 100 feet to more than 1 mile. Although the number of observations obtained on flushing and alerting distances was small (20), it appeared that the time lapse between the moment a band was first alerted and flushed varied. When caribou were suddenly alerted, the flushing and alerting distances were synonymous. The largest difference between the two distances was 500 feet. The distance at which an observer could approach a band before it flushed varied greatly with wind directions in relation to the observer and other environmental conditions.

Caribou may be approached very closely, even from an upwind direction, if the observer stalks them from behind cover.

Harper (1955) states that there is fairly general agreement on the caribou's poorly developed vision, but that in his opinion this attribute does not so much constitute poor eyesight as lack of perception and recognition. I am inclined to agree. By moving very slowly and stopping at frequent intervals, I approached caribou that were well aware of my presence. It seemed that these animals postponed flight because they could not perceive motion satisfactorily.

The reactions of caribou to sounds were tested by firing shots. A shot from a 30-30 rifle caused a band of about 60 caribou, per-

haps ½ mile away, to stop feeding and move to the crest of a hill to investigate the surroundings. These caribou soon resumed feeding. Two shots from a .22 caliber pistol disturbed a band of caribou bedded down about ½ mile away. These animals were not very much alarmed and moved off at a walking gait.

During the period when young calves were present, it became obvious that cows with calves were more alarmed by disturbances than calfless individuals.

All single cows with calves were very much alarmed by human beings. If small bands consisted exclusively or mostly of cows with calves, all animals acted much more alert and moved farther from the observer than calfless bands. If only one or two calves were present in bands including five or less cows, the cows with calves acted more alarmed than the others; in two cases, females which had calves separated from the calfless cows and ran much farther. In bands including more than five adult cows, females with calves generally continued to flee long after the rest of a band had settled. However, in one band containing 14 cows and 1 small calf, the cow which had the calf did not show any more alarm than the others when alerted.

SUMMARY

Studies were made of the behavior of barren ground caribou on their calving grounds in Mackenzie and Keewatin Districts, Northwest Territories, between May 22 and July 6, 1958. An absence of leadership was noticeable. Bands ranging in size from two to five were most frequently observed. Most bands on the calving grounds consisted largely of pregnant females. The majority of calves were born in "calving bands." The peak of calving was estimated to have occurred around June 12. As calving progressed, migratory behavior was gradually replaced by a drifting movement. By late June, caribou became increasingly restless. The attachment between a cow and her calf gradually lessened after birth. Calves 4 days old and older moved widely through a band. Daily activity reached morning and afternoon peaks. An undisturbed band seemed to have a pattern of activity and resting periods during the calving season. Calves bedded more than cows. Vocal activity increased with the state of excitation and indecision. Limited calf mortality apparently resulted from cows killing strange calves. The flushing distance of alerted caribou varied greatly with environmental conditions and band size. Cows with calves were more alarmed by disturbances than were calfless individuals.

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INITIAL SONGBIRD MORTALITY FOLLOWING A DUTCH ELM DISEASE CONTROL PROGRAM

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This paper describes the songbird mortality that followed a full-scale project to protect trees against the approach of Dutch elm disease. The observations reported here were confined in 1959 to two southern Wisconsin areas that were being sprayed with DDT for the first time.

Although it is well known that songbird mortality is very considerable following field applications of DDT in excess of 2 lb. per acre (Hotchkiss and Pough, 1946; George and Stickel, 1949; Robbins and Stewart, 1949), the changing methods of insecticidal application have left our knowledge of this phenomenon in a state of some confusion. The early appraisals of the effects of DDT on songbirds centered on foliar applications that were carried out by aerial spray or by hydraulic equipment during the birds' nesting season. Three methods have been subsequently used which have been thought to reduce this mortality during the insect-control programs.

(1) Applications of DDT during the foliar season have been reduced to 1–2 lb. per acre in some cases. Where this concentration has been used to control phloem necrosis, Barker (1958) has shown, however, that robin mortality can follow one year later. Blagbrough (1952) has concluded that foliar spraying will not seriously affect a suburban songbird population if the spraying is carried out after mid-July. Although single applications of 2 lb. per acre in June appear to have little initial effect on forest birdlife (Stewart, *et al.*, 1946), four applications at this rate and one at 1.1 lb. per acre over a 5-year period have been associated with a 26 percent decrease in the breeding-bird population (Robbins, *et al.*, 1951).

(2) Applications in excess of 1 lb. per acre have to some extent been restricted to the dormant tree season. In southern Wisconsin, contractors and government agencies desiring to control Dutch elm disease with DDT in forest and noncrop areas may exceed this concentration rate at any time from October 15 to April 15, after first notifying the State Conservation Department (Wis. State Board of Health, 1958). Here the state reserves the right to prohibit insect-control programs outside this period if the contemplated concentration is to exceed 1 lb. per acre on forest and noncrop land, although permits for such foliar spraying are granted under emergency conditions.

(3) Mistblowers have been frequently used instead of hydraulic-hose equipment. This method not only avoids puddling beneath the trees but, according to the recommendations of Chambers, *et al.* (1957), should reduce the amount of DDT required by about 38 percent.

We wish to present in this paper some observations on them which at least disclose the increasing complexity of our present program to control Dutch elm disease in the Middle West.

In order to simplify the printing of a table that follows, we have not used scientific names of mammals and birds, but have restricted our use to the vernacular names given by Hall and Kelson (1959) and by the American Ornithologists' Union (1957). Our principal study area was the University of Wisconsin campus at Madison where 735 elm trees (*Ulmus americana*) were sprayed between March 24 and April 23. Our observations following this treatment were largely restricted to a 61.2-acre tract. Here, on the eastern part of the campus, according to D. L. Anderson (pers. comm.), 49 elms were sprayed by hydraulic equipment,

[1] Among the 29 persons who helpfully contributed specimens to us for examination, we wish to acknowledge the particular aid of Mrs. J. W. Vilas, Albert Koppenhaver of the Wisconsin Conservation Department, Mrs. Timothy Brown, Jon Ghiselin, and E. M. Roark. We are also grateful to J. D. Hopkins of the Hopkins Agricultural Chemical Company and D. L. Anderson of the University of Wisconsin for detailed data on spraying operations; to the Wisconsin Alumni Research Foundation for financial assistance; and to R. A. McCabe of the University of Wisconsin and George J. Wallace of Michigan State University for critical advice.

the average tree getting 17.7 gal. of spray solution (= 2.67 lb. DDT per tree). On this same tract, 243 other elms were treated by a mistblower at an average rate of 5.4 gal. of solution (= 5.4 lb. of DDT) per tree.

At the nearby village of Maple Bluff, where hydraulic equipment was used between November 1 and April 15, approximately 3,000 elms were sprayed at an average rate of 11 gal. (= 1.7 lb. DDT) per tree (J. D. Hopkins, pers. comm.). In this community, all elm trees, including those on private property, were involved in the control program.

ROBINS

Onset of mortality.—On the campus of Michigan State University, abnormal numbers of dying robins were not noticed until 1 year after the start of the local Dutch elm disease program (Wallace, 1959). On the Madison campus of the University of Wisconsin, one dead and one dying robin in severe tremors were noticed 14 days after spraying started. However, after studying the very complete spraying records furnished us by Mr. Anderson, we regard it as highly likely that these birds died 7 days after their territories (or home ranges) were subjected to DDT. At Maple Bluff, robin mortality was recorded for us on April 12 by Mrs. Joseph W. Vilas, 15 days after her property was sprayed by the village contractor. At this time, Mrs. Vilas found 1 robin dead and 2 more robins exhibiting the typical DDT tremors prior to death.

Peak of mortality.—During the spring, the peak of robin mortality occurred on the entire Wisconsin campus during the week of April 19–25 when 27 robins were found dead and 14 others were found in severe tremors (Table 1). The peak at Maple Bluff was 1 week earlier and was presumably associated with the earlier dates of spraying in that community. Throughout the 41-day period from April 6 to May 16, it was virtually impossible for an observer to tour our 61.2-acre study tract on the campus without seeing at least one dead or dying robin, and we know that we did not secure all the dead birds on that area. Although our system of collecting specimens on the campus was an admittedly crude one, the cumulative curve of robins reported dead or dying shows a fairly constant time lag of 3 weeks behind the aggregate amount of DDT used (Fig. 1). After May 16, warm weather discouraged our cooperators in Maple Bluff from saving specimens for us.

Amount of mortality.—We have no careful bird-census data before initial applications of DDT on these two areas. On the campus, a steady decline in the robin population was evident throughout May (Table 2), and by mid-June we considered the resident population to consist of 3 pairs wholly on the study area, 2 pairs that were present along the area's boundaries and spending about one-half their time off the study area, and 1–2 wide-ranging birds that were very difficult to pin down as residents. Hence, the total number of surviving resident pairs is here taken as 4–5. These pairs occupied territories and home ranges containing very few elm trees. A rough measure of the pretreatment population can be obtained by adding these survivors to the 59 robins that we know to have died on this

TABLE 1.—CHRONOLOGY OF ROBIN MORTALITY REPORTED ON THE WISCONSIN CAMPUS AND AT THE VILLAGE OF MAPLE BLUFF

Place		Campus	Village
Spraying Dates	Start	Mar. 24	Nov. 1
	End	Apr. 23	Apr. 15
WEEK REPORTED		NUMBER OF ROBINS DEAD OR DYING	
April 5–11		4	10
April 12–18		7	31
April 19–25		41	20
April 26–May 2		18	10
May 3–9		18	4
May 10–16		17	No data
May 17–23		6	No data
May 24–30		1	No data
Subtotals			
Found dead		31	22
Found dying		81[1]	53[1]
Totals		112	75

[1] All these had the typical symptoms of DDT poisoning, and all succumbed within a few hours after being found.

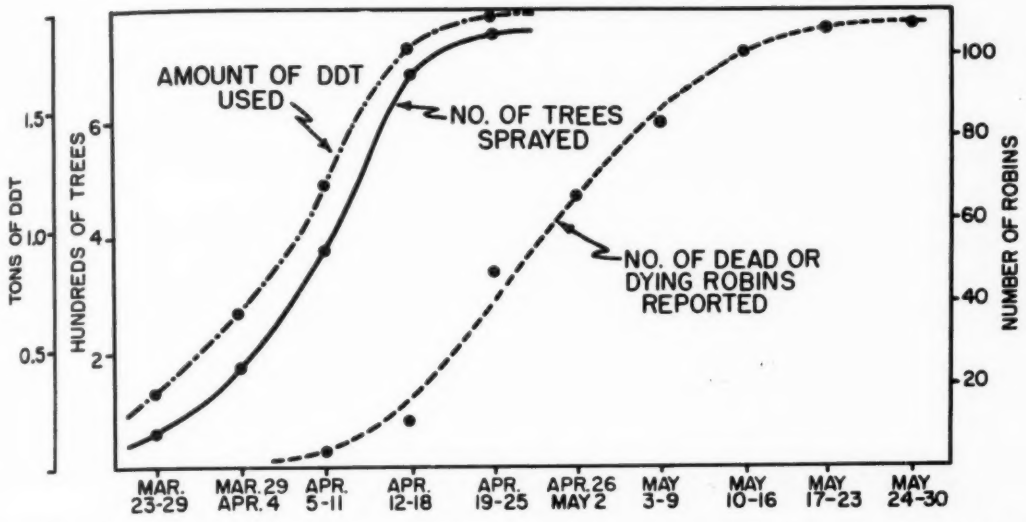

FIG. 1. Time lag between the initial use of DDT on an area and reported robin mortality. The data are on a cumulative basis. Place: University of Wisconsin campus at Madison, 1959.

particular area. When this is done, a known mortality rate of 86–88 percent is indicated. Because we received dead campus robins lacking data as to their exact site of demise and because others were regularly disposed of by the campus clean-up men, we regard this estimate as a minimal one. If the pretreatment density of robins on the campus was only one-half that found by Hunt (1960) on 119.5 acres of excellent and unsprayed robin habitat elsewhere in Wisconsin, an even higher mortality rate would be indicated. This mortality phenomenon is, of course, complicated by birds that may move onto the campus from unsprayed areas adjacent to it. Such an immediate movement of birds into a catastrophe-subjected area has been well recorded by Stewart and Aldrich (1951) and by Hensley and Cope (1951) for the latter part of the songbird-breeding season, but very little seems to be known regarding the movement of robins under similar circumstances in May.

At the present time, mean seasonal mortality rates for the robin are unknown. Farner (1945) has shown that, under ordinary circumstances, the adult mortality rate for robins averages slightly more than 50 percent per year. It seems clear that the mortality witnessed by us on the campus in April and May, 1959, was abnormally high.

OTHER SONGBIRDS

Onset of mortality.—Campus spraying began on March 24 when 63 elms were sprayed with mistblower and hydraulic equipment. On March 30, when 29 more trees were next sprayed in a similar fashion, a brown creeper was found clinging to the trunk of an elm and in severe tremors that

TABLE 2.—CONDITION OF ROBINS ON 61.2 ACRES OF CAMPUS SURVEYED IN MAY AND JUNE, 1959

DATE OF TRANSECT	NUMBER OF BIRDS FOUND[1]			
	Normal	Tremors	Dead	Totals
May 5	17	2	4	23
May 14	12	3	10	25
May 21	7	1	0	8
May 30	5(1)	0	0	5(1)
June 8	9(4)	0	0(2)	9(6)
June 12	8(1)	0	0	8(1)
June 25	12(8)[2]	0	0	12(8)

[1] These numbers refer to adult birds. Additional birds that were fledged young of the year are shown inside parentheses. The dead and dying birds in May appear also in Table 1 which covers an area larger than 61.2 acres.

[2] These include 2 adults and 5 full-grown young that were feeding on cherries on the north border of the plot. Their ingress into the study area is suspected.

were shortly followed by death (T. D. Sargent, pers. comm.). Since the initial spraying took place over 600 yards to the west, there is some possibility that this creeper succumbed to DDT on the same day on which DDT was applied to its foraging area. Mrs. Vilas, who kept a diary of events occurring on and near her property in Maple Bluff, found birds in severe tremors starting on the 15th day after her trees were sprayed. Here, during the first week of mortality on her 1.56 acres, she picked up 1 squirrel and 28 dead or dying birds belonging to five species. Nine of these had the clear-cut symptoms of DDT poisoning.

Chronology of mortality. — From the campus and Maple Bluff during the course of the spring, we received 17 specimens (exclusive of robins) that represented 11 different species exhibiting typical DDT tremors followed by death; 55 other specimens were turned over to us on the presumption that they had died of DDT poisoning (Table 3). We regard Table 3 as only a rough sample of DDT mortality following a single year of dormant spraying, and we wish to emphasize that the numbers reported here are not the result of systematic searching. It seems to us highly significant, however, that so few transient species appear in this list. As far as we can determine on our study areas at this time, dormant spraying does not importantly affect the

TABLE 3.—REPORTED CHRONOLOGY OF MORTALITY FOR ALL SPECIES

This list includes only specimens turned over to the authors. Numbers in parentheses refer to the number known to have exhibited DDT tremors. Area covered: Maple Bluff and the University of Wisconsin campus at Madison.

Species	Mar 20–Apr. 4	Apr. 5–11	Apr. 12–18	Apr. 19–25	Apr. 26–May 2	May 3–9	May 10–16	May 17–23	May 24–30	Totals
PERMANENT RESIDENTS[1]										
Common crow			1							1
Starling			2(1)	4(1)	6(2)	3(1)	1	2		18(5)
House sparrow				4	1	1				6
Cardinal			1	2(1)	2					5(1)
Gray squirrel					1					1
Eastern cottontail					1					1
Short-tailed shrew						1(1)				1(1)
MIGRANTS AND WINTER VISITANTS										
Yellow-bellied sapsucker		4(1)	1	4						9(1)
Brown creeper	1(1)									1(1)
Palm warbler					1					1
Slate-colored junco		1	1							2
White-throated sparrow					1(1)					1(1)
SUMMER RESIDENTS										
Yellow-shafted flicker		2	1	1	1					5
Blue jay[2]								1(1)		1(1)
Catbird							2(1)			2(1)
Brown thrasher								1(1)		1(1)
Robin		7(2)	17(1)	53(22)	23(6)	16(7)	8(2)	5(2)	1(1)	130(43)
Yellow warbler									1	1
Common grackle		2	1	5	4(2)	1			1(1)	14(3)
Chipping sparrow						1(1)				1(1)
Totals (excluding robins)	1(1)	9(1)	8(1)	20(2)	18(5)	7(3)	3(1)	4(2)	2(1)	72(17)
(including robins)	1(1)	16(3)	25(2)	73(24)	41(11)	23(10)	11(3)	9(4)	3(2)	202(60)

[1] Of these, the proportion of crows and starlings that spend only the "summer" in this region is unknown.

[2] Although blue jays are a permanent resident species in southern Wisconsin, most of the nesting birds in Madison arrive between April 27 and May 24 (vide Margaret B. Hickey, pers. comm.). In 1959, the ratio of wintering to nesting pairs in the vicinity of Mrs. Hickey's Madison banding station was 1.5 to 13. This 1:9 ratio does not necessarily hold for all years nor for Maple Bluff and for other parts of Madison.

great hordes of migratory songbirds that pour through this region in May.

The robin, however, appears to be a species that is quite vulnerable to DDT, even when one considers its abundance in the three unsprayed towns that we have censused in this region. Starlings and grackles were next most frequently represented among our specimens, but the less common cardinals and flickers perhaps are more vulnerable. As the nesting density of these last two species is fairly low in Wisconsin's residential communities, this phenomenon cannot be evaluated on the basis of our preliminary observations.

GENERAL COMMENT

Up to the present time, we have not assayed the DDT content of any of the dead or dying birds that are mentioned in this paper. The dying birds observed in the field all exhibited tremors that were identical to those that we produced experimentally (Hickey, *et al.*, 1960) in robins in the laboratory. For a few birds, we used a moving-picture film (Albert and Hickey, 1959) to document these symptoms of DDT poisoning in the field. On the western side of Madison in 1959, we had the opportunity to watch an undesigned but controlled experiment. North of University Avenue, where 1.9 tons of DDT were applied to elms on the campus, we found dead and dying songbirds to be a common phenomenon. South of this avenue, where there appeared to be a normal urban songbird population and where a great many unsprayed elm trees were present, this mortality was not evident. We conclude that the unusual mortality of birds on the campus was very largely the result of exposure to DDT.

Immediate effects and geographic variation.—Although Wallace (1959) reported that songbird mortality set in 1 year after Dutch elm disease control was initiated on the Michigan State University campus, it is clear from our observations that, with some of the dormant spraying of DDT now practiced in Wisconsin, the onset of this mortality can be dated from 0 to 15 days after spraying. According to Wallace (*in litt.*), relatively few elms were sprayed on the M.S.U. campus in 1954, the control program being accelerated in 1955 (when songbird mortality was first noticed), and placed on a full-scale basis in 1956. Thus, the onset of songbird mortality following the initiation of a Dutch elm disease control program will obviously vary according to the magnitude of the control program that is attempted. It is also clear from our limited field work that some species of birds seeking their food on the trunks of trees succumb quickly to DDT spraying. Although there have been scattered reports of songbird mortality due to foliar spraying of DDT for Dutch elm disease control in the eastern part of the United States (Benton, 1951; Blagbrough, 1952), it seems surprising to us that so few mortality reports have emanated from the East and that so many (Montgomery, 1956; Lobik, 1956, 1957; Larkin, 1957; Wallace, 1959; Mehner and Wallace, 1959) are confined to the Middle West.

Benton (1951) found 11 dead birds on a 20-acre New Jersey tract subjected to spraying that began on or about July 5, but he was unable to demonstrate any net population change in the density of birdlife as a result of foliar spraying at that time. In view of the experimental work of Stewart and Aldrich (1951) and Hensley and Cope (1951), we find it difficult to accept Benton's conclusion that ingress of birds onto his sprayed area did not mar his results. Blagbrough (1952) reported deposits of 130–196 lb. of DDT per acre as the result of foliar spraying to control Dutch elm disease on this same area. This residue could jeopardize robins over a period of time (Barker, 1958), but no details of Blagbrough's calculations are available, and we assume that they refer only to the immediate vicinity of the trees that were sprayed. Of the 122 dead birds picked up by Blagbrough (1952) after a March–May spraying of DDT with hydraulic equipment, 35 were robins and 31 were myrtle warblers. The conclusion of Benton (1951) and Blagbrough (1952) that prefoliar spraying before April

should not seriously kill off songbirds is not, of course, tested by our investigation; but at least one of these authors appears to have worked with a pretreatment robin population of only 50 pairs per 100 acres. Robins censused by Hunt (1960) on five unsprayed plots in southern Wisconsin communities ran 159, 161, 165, 195, and 198 pairs per 100 acres; and on a 1.52-mile transect of another unsprayed Wisconsin city, Hickey (1943: 84) found 167 pairs per 100 acres.

Movement after exposure to DDT.—Among the concepts of songbird mortality currently held by at least a part of the general public is the hypothesis that migratory birds may pick up DDT in one locality and then die with full symptoms of DDT poisoning in some distant area. In personal conversations with our colleagues, this idea has been advanced to us on the one hand to explain the presence of dead and dying birds in a sprayed community ("How do you know they did not pick up the toxicant elsewhere?"), and on the other hand to discount the absence of mortality among May migrants on the two areas that are the principal subject of the present paper.

The first of these hypotheses is met by our noting, as described above, the absence of tremor-stricken birds on areas that were not subject to Dutch elm disease control. The second hypothesis is much more difficult to answer. During the fall of 1958, we carefully inserted capsules of DDT into the gullets of captive robins. Even when the single dosages of this toxicant were as high as 450–600 mg./kg., the mortality was zero among five birds in this experiment. Coburn and Treichler (1946) similarly failed to kill starlings that were given 600 mg./kg. at a single time. When two of our control robins were given capsules containing lactose and a colored vegetable dye, the dye appeared 11 minutes later in the feces of one captive bird and 24 minutes later in the feces of the other. While the stress of handling may have temporarily and unnaturally speeded up the metabolism or the digestive processes of these birds, we completely failed to kill robins with massive single dosages of DDT under these conditions, and we tentatively conclude that a single "meal" of DDT is not the common method by which robins succumb to this compound. As there is a great deal of interspecific variation in the response to a given poison, we hesitate to extrapolate from captive robins to swiftly moving migratory songbirds. At least at the present time, the hypothesis that many birds pick up DDT at one place and die at another remains unproven. There seems to be no doubt, however, that dormant spray with mistblowing or hydraulic equipment—although it may spare May migrants—nevertheless takes a heavy toll of other birdlife.

SUMMARY

In two southern Wisconsin areas, initial applications of DDT to control Dutch elm disease during the tree-dormant season were followed by robin mortality 7–15 days later, the minimal percentage of robins dying on one area being estimated at not less than 86–88 percent. In general, robin fatalities lagged behind spray operations by about 3 weeks. Dormant spraying of DDT did not noticeably affect transient birds in May. Among the other avian species known to have been affected in the present study, a brown creeper succumbed to spraying on the same day on which a local application was made, and the starling, common grackle, cardinal, and yellow-shafted flicker seemed to be the species most affected by DDT in the 8 weeks that followed.

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THE CASSIA DEER HERD OF SOUTHERN IDAHO[1]

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The Cassia deer herd is one of the most important mule deer (*Odocoileus h. hemionus*) herds in Idaho. From 1940 to 1955 it has contributed annually from 10 to 14 percent of all the deer harvested in the entire state. During the past 70 years the deer population has cycled from virgin abundance to extreme scarcity to a long period of abundance again. Recently, after some 20 years of closure and 21 years of hunting by special permit only, it was placed in the general open season.

Traditional attempts to balance deer numbers with available forage have been only partially successful. Overuse of winter browse was reported as early as 1938, and by 1948 heavy deer use of summer forage was also evident (U.S. Forest Service, 1948). Fortunately, however, despite some continued abuse by both deer and livestock

[1] Contribution from the Idaho Cooperative Wildlife Research Unit, College of Forestry, University of Idaho; the Idaho Fish and Game Department; the Wildlife Management Institute, and the U. S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, cooperating.

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the range is still in fair condition. The high annual harvests necessary for proper range maintenance are, and have been, a matter of considerable public concern.

To appreciate fully the current status of the Cassia herd, it is helpful to know something of its history and the sequence of events that have affected the deer and their range. The following presentation attempts to furnish this background by describing important physical and vegetative features of the area, and discussing the history, management, and reproductive potential of the herd. As intended, therefore, it is more a general portrayal of an important western deer herd than a report of specific research.

DESCRIPTION OF THE AREA

The Cassia herd summers on the Cassia Division of the Sawtooth National Forest (formerly Minidoka National Forest) in extreme south-central Idaho. During the winter, part of the deer migrate south for undetermined distances into Nevada and possibly into Utah. The Idaho portion of the range comprises some 380,000 acres, of which 85 percent is within the Cassia Division and 15 percent on adjacent lands administered by the Bureau of Land Management.

The southern half of the Division is bounded by mountains, and the northern periphery extends down to the arid Snake River plains. In general the area is a deeply dissected plateau varying in elevation from 4,000 to 8,130 feet, with the majority of the main uplift exceeding 6,000 feet. The larger streams have cut canyons from 200 to 600 feet deep, and the inter-stream areas often occur as broad, flat tops bordered by abrupt escarpments and conspicuous rim rock. Lava gravel and lava rocks are conspicuously scattered over the soil surface in many localities. The soils are mostly clay loams which contain little humus material and become exceptionally dry during the summer.

Summer precipitation averages about 6 inches at elevations above 6,000 feet. Snowfall varies in depth from 12 to 18 inches in the foothills to over 6 feet on the highest parts of the forest.

VEGETATION

Vegetation is considered in terms of predominant or conspicuous cover types. The principal types, beginning with the lowest and proceeding altitudinally to the highest, are discussed in terms of relative size, common plant species, and general relationships to foraging habitats of deer. (Plant names are after Davis, 1952.)

Sagebrush

At least two-thirds of the area is dominated by sagebrush (mostly *Artemisia tridentata*) from the lowest to the highest elevations. According to Walgamott (1936), however, sagebrush was unknown in the mountains before 1880 except on low dry ridges and then only in limited growth. Its predominance today undoubtedly results from severe livestock grazing around 1900.

By virtue of its broad expanse and associated deer forage species, the sagebrush type assumes great practical importance to general herd welfare. Extensive stands of bitterbrush (*Purshia tridentata*), which occur in both pure and mixed communities within the sagebrush type, furnish the bulk of winter browse. At higher elevations associated herbaceous species contribute important summer forage. Heavy utilization of key plants by deer is common in both situations.

At higher elevations within the sagebrush type, snowberry (*Symphoricarpos* spp.) approaches co-dominance, and snowbush ceanothus (*Ceanothus velutinus*), chokecherry (*Prunus virginiana*), bittercherry (*Prunus emarginata*), and currant (*Ribes* spp.) are locally abundant. Rabbitbrush (*Chrysothamnus* spp.) and Oregon grape (*Berberis repens*) are widespread but subordinate shrubs. Serviceberry (*Amelanchier florida*) occurs in isolated clumps and is always heavily browsed.

Some common understory plants are balsamroot (*Balsamorhiza* spp.), pussy-toes (*Antennaria* spp.), yarrow (*Achillea lanulosa*), groundsel (*Senecio* spp.), elk weed (*Frasera speciosa*), penstemon (*Penstemon* spp.), bluebunch wheatgrass (*Agro-*

pyron spicatum), cheatgrass (*Bromus tectorum*), Idaho fescue (*Festuca idahoensis*), and stipa (*Stipa* spp.).

Bunchgrass

The bunchgrass-prairie type is a natural community occurring at low to intermediate elevations. It is restricted to steep slopes normally inaccessible to livestock and not well represented on the area. Bluebunch wheatgrass, Idaho fescue, and Sandberg bluegrass (*Poa secunda*) predominate, with forbs such as yarrow, balsamroot, and lupine (*Lupinus* spp.) occurring in lesser amounts. It receives moderate spring and fall deer use.

Juniper

There are approximately 15,000 acres of the juniper type along the eastern periphery of the area. Utah juniper (*Juniperus utahensis*) is widespread, and Rocky Mountain juniper (*Juniperus scopulorum*) occurs in limited growth along stream bottoms. The understory is predominantly a sagebrush type.

During the winter, deer are widely scattered throughout the juniper but noticeably less numerous than in the extensive sagebrush-bitterbrush communities in the northern foothills bordering the Snake River plain.

Mountain Mahogany

Mountain mahogany (*Cercocarpus ledifolius*) occurs in limited and isolated communities on ridgetops where soils are shallow, or on steep rocky slopes. Practically all stands have a conspicuous browse line indicating that deer prefer mahogany as winter food. Despite its high palatability, however, mountain mahogany is much too restricted to achieve any practical importance to general herd welfare.

Lodgepole Pine

Lodgepole pine (*Pinus contorta* var. *latifolia*) occupies approximately 10,000 acres and occurs in widely scattered pure and mixed communities, generally above 6,000 feet. The stands are dense, even-aged and undoubtedly a fire succession. Understories of pure stands are mostly litter or occasionally pinegrass (*Calamagrostis rubescens*), but when pine stands are mixed with aspen (*Populus tremuloides*) and alpine fir (*Abies lasiocarpa*), such plants as snowberry, currant, Oregon grape, meadowrue (*Thalictrum* spp.), elk sedge (*Carex geyerii*), and mountain brome (*Bromus marginatus*) occur. Pure stands receive moderate use as cover or resting areas, while mixed stands furnish some forage in addition.

Aspen

Aspen is the most important deciduous species on the Cassia Division. While it has distinct forage value and receives heavy summer use by deer, its chief attribute is probably its watershed value. A rich association of understory species is found beneath aspen. Shrubs such as snowberry, sagebrush, chokecherry, bittercherry, and currant are common. Conspicuous forbs are tall larkspur (*Delphinium occidentale*), serrated senecio (*Senecio serra*), stickseed (*Hackelia floribunda*), and meadowrue, along with numerous grasses. As a type, aspen is extremely important for both the protection and forage it provides.

Alpine Fir

The alpine fir type is found on moist north and east slopes on the highest parts of the forest. Occasionally present in pure stands, it is more often mixed with lodgepole and aspen. Pure stands lack the well developed understories described in the mixed communities above and receive only limited deer use.

Above 6,000 feet, where the sagebrush, aspen, lodgepole, and alpine fir types occur in close association, a characteristic mosaic of plant communities is formed. This has created an excellent dispersion of cover and forage types which facilitates exceptionally high deer densities per unit of summer range. Since desirable summer range may actually be in shorter supply than available wintering areas, this feature is an extremely

important attribute of the area. Thus, with regard to deer production it is perhaps less important to consider the integrity of the individual types than it is to stress the value of their combined, close-knit ecological diversity.

EARLY HISTORY

Several immigrant trails passed close to the present Cassia Division. All were heavily used in 1849 and 1850 and then received only moderate use until completion of the first transcontinental railroad in 1869. Permanent settlements appeared in 1870. A herd of from 300 to 400 cattle were brought into the area in 1871, and the following year 4,000 cattle were trailed in from California.

Native big game provided an abundant source of meat for both the immigrant and early settler. By 1880 bighorn sheep (*Ovis canadensis*), elk (*Cervus canadensis*), white-tailed deer (*Odocoileus virginianus*), and bison (*Bison bison*) had disappeared from the general area, but mule deer were still plentiful in the foothills.

The first indications of excessive livestock grazing were noted around 1880, but dry years and the heavy 1886–87 winter forced drastic reductions in numbers. An example is noted in the Sparks-Tinnin Company, which was reported to graze 175,000 cattle. In 1885 this company branded 38,000 calves, but in the spring of 1891 only 60 head were branded.

By 1900, cattle had again reached at least 65 percent of their former high numbers. Domestic sheep had also been increasing and by 1904 were reported to be barking young aspen trees as high as they could reach. With the creation of the Minidoka National Forest in 1905, however, grazing was regulated, and the range situation began to improve gradually. At this time the number of mule deer were only a remnant of their former numbers (U.S. Forest Service, 1942).

MANAGEMENT PROGRAM

Deer hunting was closed on the Cassia Division in 1911 but remained open outside the national forest and on the wintering areas in northeastern Nevada. The first big game census was taken in 1917 when 745 deer were reported on the area. In 1924, a 12 × 14-mile portion of the Nevada winter range was also closed to hunting. By 1928 there were an estimated 2,000 deer on the division, and in 1929 and 1930 general open seasons were held. As a result of widespread public antipathy to the open seasons, the area was closed until 1935 when the special permit hunts were established.

Since the number of permits to be issued soon proved a point of contention, a cooperative deer management program was developed in 1944 by the Idaho Fish and Game Department, U.S. Forest Service, and the old U.S. Grazing Service (now Bureau of Land Management). A series of administrative studies followed considering such items as annual census, deer carrying capacity, extent of Nevada winter range used by Cassia deer, effect of combined Idaho-Nevada harvests on the Nevada herd unit, probable rate of increase, deer weights and measurements, competition between deer and livestock, and utilization of key plants.

Controlled Hunting

The popularity, extreme accessibility and proximity of the area to population centers have made controlled hunting a longstanding practice. In 1953, for example, there were 10,320 applicants for 5,800 permits. Demand for hunting privileges decreased in the interim that followed, however, and in 1956 and 1957 general open seasons were held. Public reaction forced re-use of the permit system in 1958, but in 1959 the general open season was again effective. A total of 59,800 permits were issued and 43,038 deer were harvested under the permit system by Idaho hunters. Hunter success corrected for nonparticipation has averaged a creditable 72 percent for the entire 21-year period.

Hunting remained closed in Nevada immediately adjacent to the division from 1924 until 1941. From 1942 to 1947 open seasons were resumed, and the kill increased from about 100 to roughly 1,000 deer. In 1948 the Goose Creek special hunts were estab-

TABLE 1.—TREND COUNTS OF MULE DEER ON THE THREE ROCK CREEK COUNTING UNITS, CASSIA DIVISION, SAWTOOTH NATIONAL FOREST, 1943–53

Year	Dry Creek	McMullen	Buck-brush	Total
1943	1,466	1,826	2,388	5,680
1944	1,725	2,444	1,923	6,092
1945	1,241	3,317	1,231	5,789
1946	1,228	2,620	1,475	5,323
1947	No count, conditions unfavorable			
1948	1,123	2,338	1,088	4,549
1949	2,501	2,794	1,347	6,642
1950	2,174	3,492	1,190	6,856
1951	—	2,371	1,295	—
1952	2,219	2,704	1,012	5,935
1953	1,593	2,085	1,047	4,725

lished. Under this program 3,443 deer have been taken through 1955 with a hunter success ratio of 68 percent. The highest harvest for the combined states occurred in 1952 when 6,154 deer were removed during the legal hunting seasons.

Deer Numbers

Trends in deer numbers are determined by large scale drive censuses of natural counting units in Idaho. Since the Nevada winter range is too vast for such methods, daily counts, until recently abandoned, were made of tracks crossing a road on the major spring migration route. Most of the original counting units in Idaho have also been abandoned since their inception in 1942, and the north end Rock Creek units have been used to follow general population trends. Since this area is believed to include approximately 50 percent of the deer on the Idaho side, Table 1 is presented to show the fluctuation in numbers during the years detailed counts have been made. In 1943 and 1944, intensive counts were made of the entire winter range, and the reported populations of 13,000 and 13,600, respectively, are the most accurate past population data available for the herd (McConnell, 1957).

Extensive range inventories were conducted at this time which indicated the deer carrying capacity to be about 10,000 animals. Since carrying capacities are not stable range properties, this figure has, of course, been long discarded. Current range studies attempt to correlate trends in range condition with general trends in deer numbers as a basis for management programming. Deer numbers probably peaked around 1950, but the sharp increase in the allowable harvest in the years that followed is believed to have gradually reduced the deer population.

REPRODUCTIVE GAINS

The most reliable reproductive data come from sampling the doe population during gestation. Unfortunately, this has not yet been possible for the Cassia Herd, consequently the following data were obtained from does harvested during the hunting season, which precedes the rut by 30 to 45 days. Pregnancy and fawning were thus approximated for the breeding season preceding collection by examining ovaries for the occurrence and frequency of pigmented scars of degenerating corpora lutea (Cheatum, 1949). These data were supplemented by field examination of udders for evidence of lactation. Attempts were also made to differentiate pigmented scars from lutenized follicles by the lack of rupture sites on the ovary surface and smaller size of the latter. Additional data are needed on prenatal and postnatal losses and sex and age compositions to give a more nearly complete picture of the Cassia herd's life equation than is now available in a preliminary study by McConnell (1957).

Rocky Mountain mule deer generally first breed when about 18 months old. However, studies by Robinette, *et al.* (1955) suggest that fawns will also occasionally breed. No evidence has been found, based on ovary and udder examinations of yearlings, to indicate that fawn breeding occurred in the Cassia Herd.

Comparative pregnancy rates for does of yearling age and greater for the years 1952–56 are shown in Table 2. During this period the average pregnancy percentages for this combined group varied as follows:

1952	83.8	50 deer
1953	88.8	96 deer
1954	97.1	43 deer
1955	92.5	36 deer
1956	87.5	19 deer

TABLE 2.—COMPARATIVE PREGNANCY RATES OF MULE DEER, 1952–56, IN THE CASSIA DIVISION, SAWTOOTH NATIONAL FOREST

Age Class[1]	Number of Does	Number Pregnant	Percent Pregnant
Yearling	59	39	66.1
2-year-old	46	43	93.5
Prime (3–8 years)	124	121	97.6
Old (over 8 years)	42	41	97.6
Total	271	244	90.0

[1] Age classes after Robinette and Jensen (1950).

Although Cassia does breed intermittently as yearlings and readily at 2 years of age, sexual maturity, i.e., full reproductive capacity, was not reached until the prime (3–8 year) age class. This high level of production continued into the old (8 years and over) age class as well. There was no noticeable trend toward lower productivity among older does as has been reported in some other mule deer herds.

Pigmented scar counts, as shown in Table 3, are really only an indication of ovulation during the preceding breeding season. To predict actual fawn births the rate of ova fertilization, or proportion of fetuses to the number of corpora lutea of pregnancy, must also be known. Robinette (1956) found 475 does contained 853 corpora lutea and 789 fetuses for a fertilization rate of 92.5 percent. Additional data from Robinette (personal letter to Dalke, 1954) shows that 16 uteri from does collected 50 miles east of the Cassia Division contained 29 corpora lutea and 30 fetuses. The indicated 103.4 percent ova fertilization rate resulted from a yearling doe with twin fawns and a single corpora lutea.

TABLE 3.—ANALYSIS OF OVARIES BY PIGMENTED CORPORA LUTEA SCAR COUNTS, 1952–56, FROM SEPTEMBER HUNTS IN THE CASSIA DIVISION, SAWTOOTH NATIONAL FOREST

Age Class	Pairs of Ovaries Examined	No. Pigmented Corpora Lutea Scars Per Doe				Total No. Scars	Average No. Scars Per Doe
		0	1	2	3		
Yearling	59	20	25	14	0	53	0.90
2-year-old	46	2	21	23	0	67	1.46
Prime	124	3	18	96	7	231	1.86
Old	42	1	6	33	2	78	1.86
Total	271	26	70	166	9	429	1.58

Unfortunately, data on the frequency of ova fertilization are lacking for Cassia does. Consequently, for discussion purposes we have assumed 95 percent ova fertilization with prenatal losses from implantation to mid-pregnancy for each age class as reported by Robinette, *et al.* (1955). With this assumption the estimated average fetal rates for the various age classes of does were as follows: yearling, 0.82; 2-year-old, 1.35; prime, 1.75; and old, 1.73. Although these figures only approximate live fetuses at mid-pregnancy, they can also be used to indicate fawns produced. Robinette, *et al.* (1957) have shown that the relationship between live fetuses and corpora lutea of pregnancy remains fairly constant from mid-pregnancy to birth.

Estimated average pregnancy and fetal rates were 90 percent and 1.41 respectively for Cassia does of yearling age and greater. This is nearly comparable with the 91 percent pregnancy rate and 1.52 fetal rate reported for the same age groups in Utah. Prime and old Cassia does were more productive than Utah deer, but this was not true among younger animals. Only 66 percent of Cassia yearlings were pregnant, with an estimated fetal rate of 0.82. This was considerably less than the 89 percent pregnancy rate and 1.11 fetal rate reported for Utah yearlings. While 93 percent of the Cassia 2-year-olds conceived for 1.35 fawns each, 99 percent of the Utah herd were pregnant with a fetal rate of 1.76. The lower production among younger Cassia does could be taken to indicate that range conditions have deteriorated to the point where reproduction is being depressed, but there is little supporting evidence.

Table 4 lists some probable fecundity rates for the Cassia herd based on the frequency of pigmented scars. They have not been corrected for ova fertilization or prenatal loss. Robinette, *et al.* (1955) state that ova mortality increases with litter size, consequently the twin and triplet percentages in Table 4 are probably high and the

TABLE 4.—AVERAGE FECUNDITY OF THE CASSIA DEER HERD FOR THE 1952–56 BREEDING SEASONS AS INDICATED BY PIGMENTED CORPORA LUTEA SCAR COUNTS

Age	Total No.	BARREN		SINGLES		TWINS		TRIPLETS	
		No.	Percent	No.	Percent	No.	Percent	No.	Percent
Yearling	59	20	33.9	25	42.4	14	23.7	0	0.0
2-year	46	2	4.3	21	45.6	23	50.0	0	0.0
Prime	124	3	2.4	18	14.5	96	77.4	7	5.6
Old	42	1	2.4	6	14.3	33	78.6	2	4.8

single and no-fawn percentages are probably low.

In general, the foregoing discussion has indicated (1) that as far as deer ranges go, the Cassia range is still in fair condition; (2) that the deer harvests have been substantial and have probably checked, if not decreased, the deer population; and (3) that the deer are numerous and productive. Unfortunately, the off-hand implication that deer numbers and deer forage are approaching close harmony is not so easily justified. An equilibrium of sorts is undoubtedly being effected, but some precarious teetering may still be encountered before a proper balance is finally achieved.

SUMMARY

During the years 1940 to 1955 the Cassia herd contributed annually from 10 to 14 percent of all deer harvested in the state. The sagebrush type occupies over two-thirds of the area from the lowest to the highest elevations. Lodgepole pine, aspen and alpine fir comprise about 25 percent of the area and grow in close association with the sagebrush type above 6,000 feet. The resulting closely knit mosaic of cover and forage types facilitates exceptionally high summer deer densities per unit area of range. Both summer and winter ranges show signs of heavy deer use.

Pregnancy varied from 66 percent in yearlings to 98 percent in deer over 3 years old. The combined pregnancy rate for does of yearling age and greater was 90 percent. Estimated fetal rates were 0.82 for yearlings, 1.35 for 2-year-olds, 1.75 for prime and 1.73 for old does. The average fetal rate for the combined age groups was 1.41.

Although a rough balance is probably being achieved between the herd and its range, much work remains to be done to add to the knowledge of herd productivity and range carrying capacity.

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PROBLEMS ASSOCIATED WITH PRACTICES THAT INCREASE THE REPORTED RECOVERIES OF WATERFOWL BANDS

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It is common knowledge among waterfowl banders that only a portion of the banded waterfowl that are bagged are reported to the banding office of the Bureau of Sport Fisheries and Wildlife. Bellrose (1945, 1955) estimated that perhaps fewer than half of the bands that are taken by hunters are reported. Geis and Atwood (1959) calculated the proportion of banded bagged waterfowl reported by species and areas.

Because so many of the banded birds that are shot are not reported, a number of proposals have been made and actions taken to increase the proportion reported. The purpose of this paper is to demonstrate that serious problems are introduced by some of these activities.

Waterfowl are banded for various purposes: (1) to study the movements of the birds, (2) to estimate total mortality rates, (3) to estimate rates of exploitation, and (4) to estimate the size of a population. Good data could be obtained on all these subjects if reports were received on all the banded birds that were shot. Of course, not all of the bands recovered by waterfowl hunters have ever been returned, and it is highly unlikely that they ever will be in the future. Consequently, biologists must continue to use the more limited reports that are available. Three categories of data will be discussed in the present paper:

1. Bagged banded birds reported—the number of bands from a given banded sample that are reported to the banding records office during a given period and/or from a given area.
2. Total banded birds bagged— the total number of banded birds from a given banded sample that are bagged during a given period and/or from a given area, regardless of whether or not they are reported.
3. Reported ratio—the proportion of the total number of banded waterfowl shot and bagged that are subsequently reported to the banding records office.

The reliability of information based on reported banded birds bagged depends on the extent to which the following conditions are met:

1. The reported ratio is uniform during all years of the entire period of interest.
2. The reported ratio is essentially the same within all parts of each area of interest.
3. The reported ratio is known for each area of interest.

If the first two conditions are met, the reported ratios will always have the same relationship to total banded birds bagged in each area of interest, and mortality and distribution studies based on these data will be meaningful. In addition, it will be possible to measure the reported ratios for various areas of interest.

Most analyses of band-recovery data have been based on the assumption that the reported ratio was constant. To test this important assumption, Geis and Atwood (1959) made a study to obtain an estimate of the reported ratio and to determine if it was essentially a constant. It soon became obvious that it was not. In fact, there were numerous cases in which tests for homogeneity showed that the reported ratio was significantly different from the expected reported ratio. This variability prompted an investigation of its cause. The first possible explanation came when it was noted that the states differed greatly in the portion of the reported recoveries that came from sources other than hunters. Most of these other sources were personnel of state and federal conservation agencies.

TABLE 1.—VARIATION IN THE PROPORTION OF BANDS REPORTED FROM BANDED DUCKS BAGGED DURING THE 1954–56 HUNTING SEASONS

	Area I	Area II	Area III
Proportion reported by hunters (average percent and range)	63 (46–66)	73 (67–83)	89 (84–96)
Number of states	5	22	21
Total bands reported	19,884	18,336	18,536
Est. total banded ducks bagged	32,210	35,823	38,857
Est. proportion of banded ducks bagged that were reported (all sources)	48	51	62
Est. proportion of banded ducks bagged that were reported by hunters	50	43	45

To test the hypothesis that the reported ratio was different from the expected reported ratio, the band reports were divided into three groups; those from states having similar proportions of reported recoveries from hunters were grouped together. The reported ratio was estimated for each group. Details of the estimating procedures and the names of the states in each group are given by Geis and Atwood (1959). Data in Table 1 show that the area having the largest proportion of reports from hunters had the lowest reported ratio, while the area having the lowest proportion of reports from hunters had the highest reported ratio. This led to the question of what proportion of the reported ratio was attributable solely to hunter reports. This was estimated and is shown in the last line of Table 1. It is significant that the variability of the reported ratio among different areas is reduced when the influence of bands reported by sources other than hunters is removed.

Variability in reported ratios is produced also by various types of activities that are directed toward increasing the number of bands that are reported. The effects of these activities will be discussed in the sections that follow. Documentary data were taken from the files of the banding office of the Bureau of Sport Fisheries and Wildlife.

ORGANIZED BAND-COLLECTING PROGRAMS

One activity that introduces a serious bias error in recovery records is the practice of recording and reporting all bands that are detected at checking stations, rather than permitting the hunters to report the bands of their own volition. This practice can increase the reported ratio significantly, because all bands that are found are reported, whereas hunters by themselves may report no more than half the bands they find. If half the ducks taken in a given area passed through a checking station, then the reported ratio would be about 50 percent greater than if only the hunters reported bands.

A similar bias error is introduced when wardens report all bands they find during law enforcement activities, or when biologists report all bands they observe during certain field studies. Such activities by wardens and biologists have been carried out in every flyway; the intensity of the effort varies between years and between different areas during the same year. For example, the proportion of bands reported by hunters in the Pacific flyway during the period 1950–56 differed each year from the proportion reported to the banding office by other sources, almost all of which were state and federal conservation agencies, but the differences were not the same each year. Instead they fluctuated in a manner that was highly significant statistically, as shown in Table 2. During the earlier years the proportion reported by state and federal agencies was lower than would be expected if the band collecting activities had been constant, and in later years it was higher.

TABLE 2.—VARIABILITY OF SOURCES OF BAND RECOVERY BETWEEN YEARS IN PACIFIC FLYWAY

Year	Recoveries From:		Total Recoveries	Expected:		Chi-square
	Hunters	All Others[1]		Hunters	All Others	
1950	125	56	181	118.5	62.5	4.130[2]
1951	150	35	185	121.1	63.9	18.483[3]
1952	93	42	135	88.4	36.6	0.649
1953	240	137	377	246.9	130.1	0.479
1954	301	185	486	318.2	167.8	2.538
1955	504	275	779	510.1	268.9	0.177
1956	537	298	835	546.8	288.2	0.458
Totals	1950	1028	2978			26.914[3]

[1] Almost entirely from State or Federal conservation agencies.
[2] Significant at the 0.05 level.
[3] Significant at the 0.01 level.

In the Pacific flyway during the same period, there were also highly significant differences in band-collecting activities in the different states (Table 3). The sample was influenced strongly by the data from California because 67 percent of the recoveries reported from the entire flyway were from that state. There was significantly less band-collecting activity in Idaho, Oregon, and Washington than would be expected, whereas there was significantly more in Utah. If an equal number of reports had come from each state, the variability would have been even larger than indicated in Table 3.

The above data clearly show that band-collecting programs are of uneven intensity, and that there is a much higher probability of bands encountered in these programs being reported than there is for bands encountered solely by hunters. For these reasons, it is obvious that band-collecting programs will increase the reported ratios by varying amounts, and thus bias the data so that the first two conditions necessary to obtain reliable information are not met, i.e., the reported ratio is uniform during all years of the entire period of interest, and the reported ratio is essentially the same within all parts of each area of interest.

If these biased data are used to estimate total mortality rates or shooting mortality rates, they will introduce errors that result in inflated estimates of the proportion of a population that occurs in the area where the intensive band collections were made. These bias errors also make it impossible to combine data from separate states, and present meaningful comparisons between parts of states or groups of states. A specific ex-

TABLE 3.—VARIABILITY OF SOURCES OF BAND RECOVERY BETWEEN STATES IN PACIFIC FLYWAY

State	Recoveries From:		Total Recoveries	Expected:		Chi-square
	Hunters	All Others[1]		Hunters	All Others	
Arizona	19	8	27	17.6	9.4	0.132
California	1275	703	1978	1288.0	690.0	0.347
Idaho	213	70	283	184.0	99.0	12.618[2]
Nevada	33	22	55	35.8	19.2	0.422
Oregon	213	69	282	183.6	98.4	13.036[2]
Utah	75	129	204	132.8	71.2	70.836[2]
Washington	122	29	151	98.3	52.7	15.687[2]
Totals	1923	1030	2953			113.078[2]

[1] Almost entirely from State or Federal conservation agencies.
[2] Significant at the 0.01 level.

ample of the serious bias effects of band-collecting programs is shown in Table 4, where the sources of band reports from two highly important waterfowl wintering areas—California and Texas-Louisiana—are compared. In the Texas-Louisiana area, only 9 percent of the total recoveries were reported by state and federal conservation agencies, but in California 31 percent of the recoveries were from this source. The difference shows that there is a more intense band-collecting program in California than there is in Texas-Louisiana. Band-recovery data from the Texas-Louisiana wintering area, therefore, are not comparable to those from the California wintering area. When these band recoveries are used to make comparisons of actual shooting mortality or concentrations of the population in the two areas, the results for California will be exaggerated.

It seems appropriate to point out that some of the difference in the increase in the reported ratios between states results from the fact that the number of state and federal conservation agency employees, active during the hunting season, is much greater in some states than in others. Hence, not only are absolute numbers greater, but in some states the ratio of conservation employees in the field per 100 hunters is also greater than in others. Therefore, the probability of contact between conservation agency employee and hunter is considerably greater in some states than in others. Where this situation occurs, reported ratios will not be comparable to other areas, even if band-collecting initiative does not come from the conservation agency employees.

A second example shows the effect of variations in intensity of band collections in the same area in different years. In Missouri, the proportion of the reported recoveries that came from state and federal conservation agency personnel increased sharply, from 27 percent (15–38)[1] during the 1951–53 hunting seasons to 52 percent (46–56)[2] during the 1954–56 hunting seasons. Meaningful comparison between years cannot be made from these data or from the data gathered in any state during periods when intensive band-collecting programs are carried out.

Band-collecting programs also affect the reported ratio for different species of ducks. During the period 1954–56, the reported ratio for the black duck was 0.49, whereas it was 0.65 for the pintail. It is believed that the difference between the reported ratios for the two species was caused by differences in the proportion of the reported recoveries that came from employees of state or federal conservation agencies, because 29 percent of the pintail reports and only 14 percent of the black duck reports were from this source. Banding records reveal that most pintail band recovery reports were received from Pacific flyway states, principally California. During the period 1954–56, four of the five states having the highest proportion of bands from all species reported by sources other than hunters were in the Pacific flyway, where the pintail is usually the most common waterfowl species. During the period 1950–56, the average proportion of bands from all species reported by sources other than hunters in this flyway was 34.5 percent and 36.0 percent in California (Tables 1, 2 and 4). In California during this period, 87 percent of the reports by sources other than hunters were from state and federal conservation agency employees. The black duck occurs principally in states east of the Mississippi River, and most of the recovery records of this species have been received from this region. During the period 1954–56, only one of the five states having the highest proportion of bands from all species reported by sources other than hunters was in this area. However, most of the black duck recovery reports were from states included in a group of 21 having the lowest proportion of bands from all species reported by sources other than hunters. This group averaged 10.7 percent, and the remainder came from among 22 states where this average was 26.6 percent (Table 1).

The available information indicates that

[1,2] Numbers in parentheses are 0.95 confidence limits.

TABLE 4.—SOURCES OF BAND RECOVERY REPORTS FROM VARIOUS AREAS[1]

Source of Recovery	California 1950–56	Texas and Louisiana 1950–56	Utah 1954–56
Hunter	64.0 (62–67)[2]	82.0 (79–85)[2]	37.0 (29–45)[2]
State conservation employee	23.0 (21–25)	6.0 (4–8)	12.0 (7–18)
Federal conservation employee	8.0 (6–10)	3.0 (1–5)	17.0 (11–24)
Outdoor writers for newspapers	0.4 (0.1–0.8)	0.5 (0.2–1.5)	29.0 (22–37)
Other sources	4.0 (3–5)	8.0 (6–10)	5.0 (2–9)

[1] Based on a random sample of recoveries from waterfowl banded on national wildlife refuges.
[2] Numbers in parentheses are 0.95 confidence limits.

the greater reported ratio for the pintail resulted mostly from a greater increase in reported recoveries from band-collecting programs in the area of major occurrence of the pintail during the hunting season, as compared to the lesser increase in reported recoveries from band-collecting programs in the area of major occurrence of the black duck. The wood duck, with a range very similar to the black duck, also had an estimated reported ratio of 0.49 during this period. Additional examples of different estimated reported ratios between species are presented and discussed by Geis and Atwood (1959).

If it were possible to estimate annually the reported ratio for each species in each area of interest, the current problem of variability between areas, years, and species would be solved. However, annual estimates by species for even a limited number of areas of interest are not economically feasible. For example, with such a limited objective as only 15 areas and 10 species, the costs would be more than 30 times as expensive as the current mail survey of waterfowl hunters of the Bureau of Sport Fisheries and Wildlife. On the other hand, if there is very little variability between areas between years, it is possible to accumulate an adequate sample for each species over a period of years at no extra costs. Geis and Atwood (1959) have shown that reported ratios from reports by hunters are much less variable between areas, years, and species than are reported ratios based on all sources of shooting recovery reports. Thus the reliability of estimates of reported ratios will be increased as the variability caused by band-collecting activities is decreased.

PUBLICITY CAMPAIGNS

Increased publicity is often proposed as a method for encouraging people to report banded birds. If publicity could be distributed evenly it would be desirable. Several types of uniform publicity have been proposed and considered. Examples are: (1) printing an appeal on the edge of the duck stamp to report bands, (2) placing the request to report bands in a more prominent position in the regulations bulletin and on the regulations poster that is displayed in the post offices. This second proposal has been put into effect. Even these proposals for uniform publicity are not entirely satisfactory because they are uniform only for the United States.

Publicity that is not uniform may detract seriously from the value of banding data. Publicity campaigns sponsored by local sports writers and banders are in this category. For example, bird-banding organizations and other groups distributed posters showing a comic strip character soliciting the return of bands. As the distribution of posters was not uniform, the campaign probably contributed to bias errors in reported ratios.

Another example concerns the publicity activity of a sports columnist in Utah. During the 1953 hunting season, this columnist began requesting readers to send him band reports, which he then forwarded to the banding office of the Bureau of Sport Fisheries and Wildlife. Table 4 includes data showing the effects of this program. During

the 1954–56 hunting season, 29 percent of the recoveries in the sample from Utah we examined were submitted by this outdoor writer. In contrast, less than 1 percent of the recoveries from Texas-Louisiana and California were submitted by sports writers. During the same period, 30 percent of the recovery reports from Utah were submitted by employees of conservation agencies; only 37 percent were submitted by the hunters themselves. For the 1956 season alone, the outdoor writer submitted 40 percent of the bands, while all hunters personally reported 31 percent of the total bands reported. Because of these biased reports, recoveries from Utah in this period are not comparable to those from other areas. Furthermore, year-to-year comparisons of recovery reports on Utah alone are questionable for this period also. Chi-square tests showed that the recoveries reported as the result of the sports columnist's activities were significantly less prior to 1953 than expected during the entire period, and that there was a probability of only 0.066 that the variability during the entire period could be due to chance. As the outdoor writer contributed a large proportion of the reported recoveries for the state, there is good reason to believe that his publicity program increased the bias of the reported ratio for the years 1953–1956.

We wish to emphasize that the good intentions of the individuals concerned are not questioned in the above examples.

REWARD BANDS

The use of reward bands has been proposed as an approach to increase the reported ratio. In recent years it has been the policy of the Bureau to discourage this practice. The reasons for this policy are:

1. The use of reward bands is likely to jeopardize the regular banding program, for if it is known which bands yield a reward, it is inevitable that the reporting rate of regular (non-reward) bands will be reduced.
2. A reward-band program is difficult to administer properly. The use of reward bands requires continuous and dependable financial backing. The financial obligation incurred by placing reward bands on birds is unknown and is for an indefinite period. For example, reward bands placed on ducks in 1948 are still being returned despite the fact that there are no current provisions for paying the reward. Organizations that depend on appropriated funds may find it impossible to guarantee the necessary continuity of funds to complete a reward-band program. If any reward banding were permitted, it would have to be on a limited scale to permit sound financing. There would then be a serious problem in deciding when to grant permission for the use of reward bands and how to prevent the errors of nonuniform distribution.
3. Information obtained from reward bands is difficult to interpret. It is likely that economic differences between areas or periods of time would complicate the interpretation of reward-band recoveries. During times of general prosperity, fewer reward bands might be sent in than during a depression. Economic differences between one country and another, or even between different parts of the United States, also could produce nonuniform reporting of reward bands. Recovery data might then have a positive bias in some areas and a negative bias in other areas, and so affect calculation of bird distribution and hunting mortality. It is very likely that these and perhaps other bias errors would be introduced by the use of reward bands.
4. Information that might be obtained by a reward-band program can probably be obtained by other methods. One method is the Bureau's waterfowl hunter survey, which can be used to obtain information on the proportion of banded birds shot that are reported, and to calculate differences in reporting rates between areas and years.

LUCKY BAND PROPOSAL

Another approach is one which would establish a substantial reward for the person who returned the lucky band. Advocates of this plan believe that it would be supported by sporting goods manufacturers, breweries, and other organizations that cater to sportsmen, and this probably is true. It seems highly improbable, however, that the amount of publicity would be uniform throughout the continent or over a span of many years. Since the program could not be controlled, most of the problems involved in publicity campaigns and reward-band programs would be present in this plan also.

Several years ago a brewery in the Midwest conducted a band-reporting contest. This contest was particularly undesirable because of two conditions for entry. In order to be eligible to win, the band had to be (1) taken within 15 miles of a certain city and (2) taken during the first 2 weeks of the season. Thus, the contest would bias not only the reported ratio but also the accuracy of reported locations and dates. It was impossible to make a statistical evaluation of the effects of this contest because of complications introduced by other band-collecting programs in the area and by reports involving many hand-reared ducks.

COLOR MARKING

Waterfowl are color marked for special local studies. We do not know, at present, what effect these marking programs may have on band recoveries. We do know that the recovery rate of some color-marked birds is suspiciously high, and it seems quite possible that extensive color-marking programs may reduce the reliability of band-recovery data. For this reason, it is highly desirable that the effects of color marking be evaluated.

DISCUSSION AND SUMMARY

The reliability of information based upon banded birds bagged which are reported depends upon the extent to which the following conditions are met:

1. The reported ratio is the same between years within the same areas of interest.
2. The reported ratio is essentially the same between different areas of interest.
3. The reported ratio is known for each area of interest.

If the first two conditions are met, the banded birds bagged which are reported will always have the same relationship to total banded birds which are bagged. Under these conditions the reported ratio is substantially a constant, and, once it is determined, the investigator could use this ratio for estimating the total number of banded birds bagged.

Currently, the necessary conditions leading to the above relationships are not being met, and the situation with respect to reported ratios is as follows:

1. The reported ratio is different between years within the same area of interest. This situation is common but its limit is unknown.
2. The reported ratio is different within the same year between different areas of interest. This situation is very common but its limit is unknown.
3. The reported ratio is different between waterfowl species. The difference between several species has been demonstrated.
4. The reported ratio is not known for each area of interest. Because of item 2 above, the potential number for different reported ratios is as large as the number of areas of interest. The large number coupled with their lack of constancy (item 1 above) has created a very difficult problem relative to determining reported ratios for all areas of interest.

A number of activities which contribute to increased variability in the proportion of bands taken that are reported include: (1) band reports from those conservation agency employees who make particular efforts to report all the bands they note at checking stations, or in other special band-collecting programs in which efforts vary from area to area and from year to year;

(2) publicity campaigns, which are sporadic and not uniform; efforts of writers of some sports columns have had serious effects because of their strong influence; (3) reward-band programs, which are difficult to administer and finance, and which are almost certain to have variable effects in different areas and different years; (4) lucky-band contests which have the disadvantages of both (1) and (2). There is some evidence, also, that color-marking programs may have an effect on band returns, and it is suggested that these effects be evaluated.

In view of the above, the chances appear good for obtaining a substantially constant reported ratio in the same area of reference between years by removing these activities. It is believed that the reliability of information based upon banded birds bagged which are reported will be increased in proportion to the degree to which the above practices are decreased.

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MIGRATION PATTERNS OF THE SUN RIVER ELK HERD, MONTANA[1]

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One of Montana's largest elk herds ranges south of Glacier National Park in the upper drainage of the Sun River. Near to extinction at the turn of the century, the Sun River herd increased by 1930 to its present level of about 3,000 (Rognrud, 1950). The harvest from this herd during the hunting seasons of 1957 and 1958 was about 850 and 650 head, respectively. The elk range in summer along the Continental Divide in the heart of the 990,000 acre Bob Marshall Wilderness. The winter range utilized by most of the herd is located 14 miles west of Augusta in Lewis and Clark County. This winter range consists of about 18,000 acres of land purchased by the Montana Fish and Game Department for use by elk.

To aid in continuing the management of this herd, a study of its movements and relations to vegetative types was undertaken. This study was conducted on a full time basis from June to September of both 1957 and 1958, with supplemental observations made at other times during the period February 25, 1957 to November 26, 1958. The writer was employed by the Montana Fish and Game Department under project W-74-R during the study.

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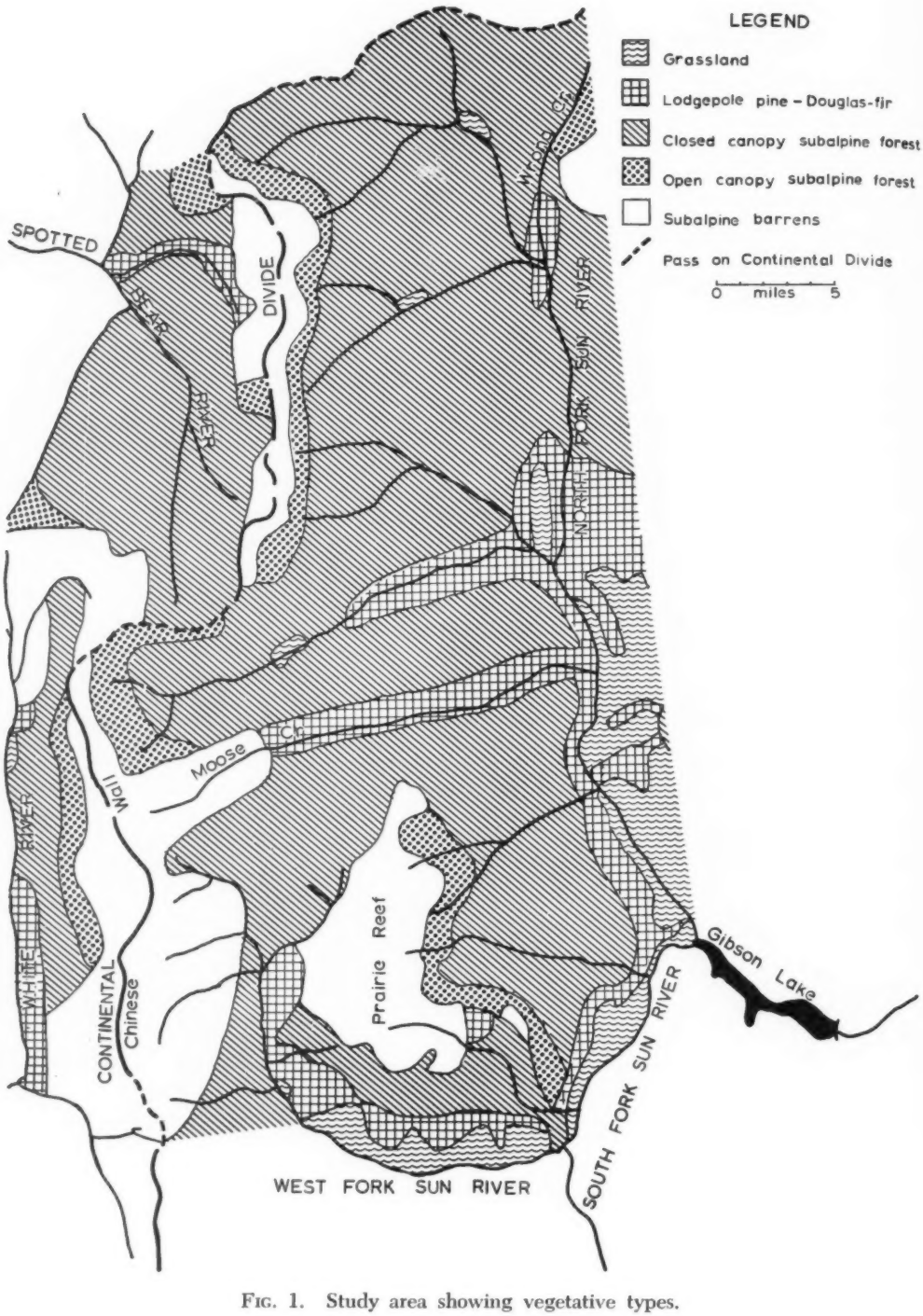

FIG. 1. Study area showing vegetative types.

to Don C. Quimby, Montana State College, who directed the study and aided in the preparation of the manuscript.

METHODS

Two different types of colored plastic ear markers were used to permit the field recognition of individual animals in movement studies. The types of markers used were ribbon markers similar to those used by Egan (1957) on deer and by Rouse (1957) on elk, as well as sheet plastic markers (Johnson, 1951). During the winters of 1957 and 1958, 163 elk on their winter range were captured in corral type traps, and during the calving seasons of these years, 27 newborn elk calves were marked. Records of the Montana Fish and Game Department indicated a few animals in the herd had been marked before 1957.

The marked elk were identified in the field with the aid of binoculars and a 20 power spotting scope. Tag recoveries from 49 hunter-killed elk were made at the checking stations.

The elk herd was followed to its summer range. Saddle horses and a pack string were used to establish base camps from which the majority of observations were made while on foot. The passes used by elk to cross the Continental Divide were periodically checked for tracks during the summer, and again after the September hunting season opened west of the Continental Divide. An index to the rate of the late fall migration of 1957 was provided by weekly ground trend counts on the winter range, which was closed to hunting after November 1.

The basis for the vegetative description of the study area was provided by aerial observations supplemented by ground travel. A more detailed study of certain vegetative features was made in the upper basin of Moose Creek drainage (Fig. 1). Twenty, 2×5 decimeter plots were selected along two, 100-foot transects in each of three vegetative subtypes. Plant coverage in the plots was determined by ocular estimate (Daubenmire, 1959). These transects were intended to provide a rough illustration of the subtypes present rather than a detailed analysis of their species composition. An indication of the elk use received by the area was given by pellet group counts made on a 4-foot strip along each transect. All elk observations made during the study were recorded by the vegetative types occupied.

STUDY AREA

The known range of the Sun River elk herd includes about 1,200 square miles of rugged terrain in the upper portions of the Sun River, and on the western side of the Continental Divide, the adjacent portions of the South Fork of the Flathead, and the Middle Fork of the Flathead River drainages.

The typical mountain topography consists of parallel reefs or ridges running north and south. These reefs slope toward the west but are very abrupt on the east. The cliffs of the eastern faces are as much as 1,000 feet in height. Because of this topography, the elk migration, which is primarily east and west, is confined to certain routes determined by passes through the reefs.

The area selected for the summer studies consisted of about 350 square miles of the northwestern corner of the Sun River drainage as well as adjacent portions of the White River and Spotted Bear River drainages of the South Fork of the Flathead River system (Fig. 1). The eastern boundary is formed by the North Fork of the Sun River which flows in a broad valley at an elevation of about 5,300 feet. From this valley, the terrain slopes up on the west and south to the Continental Divide, formed by the 8,500 feet peaks and ridges of the Lewis and Clark Range. According to Deiss (1941), this range was formed by the Lewis overthrust which placed Proterozoic and Paleozoic shales and limestones on top of the much younger Mesozoic sediments. The eastern face of the Continental Divide is a row of glacially sculptured cliffs of Paleozoic limestone which underlies the White River basin to the west. In the southern half of the study area, these 1,000-foot cliffs, known as

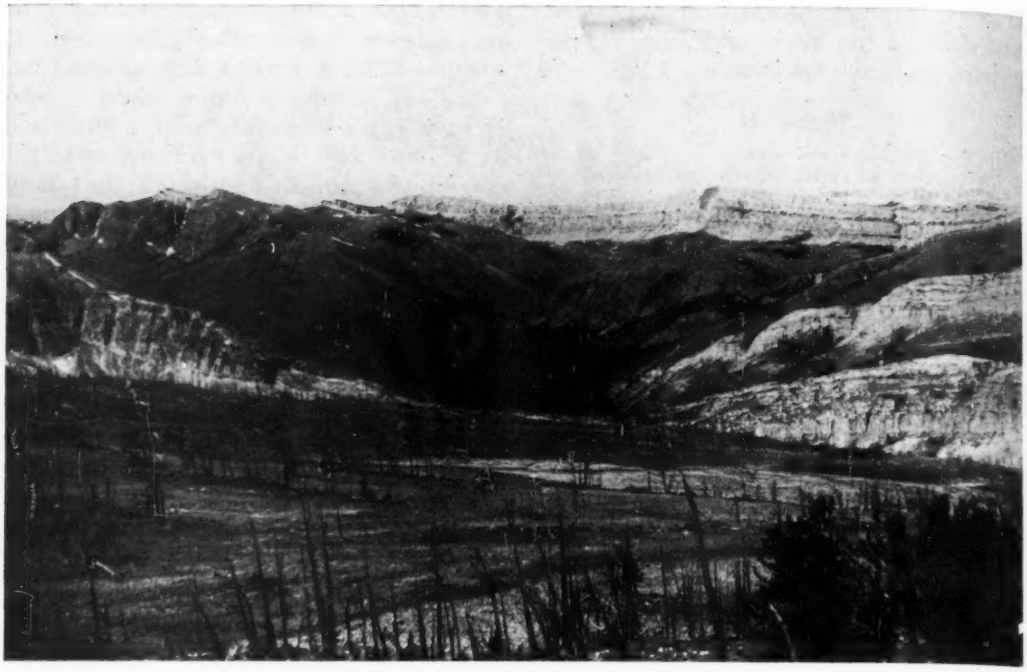

FIG. 2. Burned over areas of subalpine barrens in the foreground with the Chinese Wall of the Continental Divide in the background.

the Chinese Wall (Fig. 2), form a barrier 15 miles long which can be crossed only through one minor pass. Major pass areas exist at each end of the Chinese Wall. In the northern half of the study area, the Continental Divide continues as a series of cliffs which can be crossed through four major and two minor passes. The section of the Continental Divide which forms the northern edge of the study area is a forested ridge readily crossed by elk (Fig. 1).

The entire study area lies within the Bob Marshall Wilderness from which motor driven and wheeled vehicles have been excluded. The area lying between the North and South Forks of the Sun River and the Continental Divide is in the Sun River Game Preserve, established in 1913 to protect the Sun River elk herd.

The described winter range of the herd is located at an elevation of about 5,000 feet in the warm chinook belt along the eastern edge of the mountains, where they rise abruptly from the Great Plains.

Vegetation

In this study, five vegetative types and three subtypes were recognized (Fig. 1).

Grassland type.—This type covered a relatively small portion of the study area at elevations from 4,800 to 5,300 feet. The southern half of the area adjacent to the North Fork of the Sun River was the most extensive area covered. Usually the type consisted of grassy flats with scattered aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta*). Several large areas had been seeded to timothy (*Phleum pratense*) as an erosion control measure following the elimination of cattle grazing in the early 1930's (Cooney, 1940). Some of the characteristic native plants were bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), and shrubby cinquefoil (*Potentilla fruticosa*), giving this type a resemblance to the bunchgrass prairie of the winter range.

Lodgepole pine–Douglas-fir type.—In

general, this type formed a belt surrounding the grasslands and intergraded at higher elevations into the spruce–fir subalpine forest. Engelman spruce (*Picea engelmanni*) and alpine fir (*Abies lasiocarpa*) occupied the more mesic sites. The lodgepole pine–Douglas-fir (*Psuedotsuga menziesia*) type occupied relatively little area but was found in scattered stands throughout the study area. The chief character used in its recognition was the presence of an understory of pinegrass (*Calamagrostis rubescens*). It was previously classified by Cooney and Redman (1934) as "coniferous timber with food."

The use of the subalpine forest by elk is differentiated by noting their presence in the closed-canopy or open-canopy types.

Subalpine forest–closed-canopy.—This was the predominant vegetative type of the study area. It consisted of Engelman spruce and alpine fir with whitebark pine (*Pinus albicaulis*) on the high exposed slopes. The understory was characterized by a paucity of both plant numbers and species. Heartleaf arnica (*Arnica cordifolia*) was scattered through the forest, and on some sites wild gooseberry (*Ribes inermis*) and smooth menziesia (*Menziesia glabella*) were found. This type was classified by Cooney and Redman (1934) as "coniferous timber without food."

Subalpine forest–open-canopy.—Trees were present in some locations at all elevations in the study area. The scattered Engelman spruce and alpine fir of this vegetative type formed the upper border of the forest. A burn being reforested was regarded as a forest when the trees were tall and frequent enough to hamper a view beyond a hundred feet. Limber pine (*Pinus flexilis*), lodgepole pine and whitebark pine were common on old burns. The understory consisted of a beargrass (*Xerophyllum tenax*)–low red huckleberry (*Vaccinium scoparium*) union, with a lush forb type in the wetter areas. The characteristic plants of the forb areas were profuse amounts of butterweed (*Senecio triangularis*) and scattered plants of green false hellebore (*Veratrum viride*).

Subalpine barrens type.—This type extended from a low of 6,500 feet to the high ridges above the forest. Included in this type were the natural treeless areas of the ridges and high basins as well as several

TABLE 1.—VEGETATIVE COMPOSITION AND SUBTYPE USE BY ELK OF THE MOOSE CREEK STUDY AREA

Observations in Subtypes	Subalpine Barrens Subtypes					
	Beargrass		Mixed		Forb	
	C[1]	F[2]	C	F	C	F
Vegetative components						
Beargrass	35	90	27	50	5	5
Low red huckleberry	16	70	0	0	0	0
Forbs	16	95	34	100	80	100
Grasses	1	10	13	70	0	0
Sedges	10	55	9	35	0	0
Bare ground	13	55	23	75	15	95
Percent of Moose Creek study area covered by subtype	50		30		20	
Total elk pellet groups along two, 100-ft. transects	7		40		26	
Elk observed on subtype (1957–58 combined)						
June	3		53		69	
July	1		76		213	
August	1		42		98	
September	0		40		0	

[1] Average coverage of 20 plots, 2 × 5 decimeter, in percent (± 10 percent).
[2] Frequency of occurrence in 20 plots, 2 × 5 decimeter, in percent.

large burns, 40 to 50 years of age, in the southern half of the study area which had not grown back into forest (Fig. 2). These were the "non-restocking burns" of Rognrud (1950).

A special area was selected in the burned over upper basin of Moose Creek to study the three subtypes of the barrens. The basin appeared to be typical of the barrens and the vegetative groupings similar to the unburned as well as the burned areas. The Moose Creek area was reported to have been burned in 1918 (Hazel, 1957), but very little forest reproduction was present in spite of this 40-year interim. The results of the vegetative analysis are presented in Table 1.

Beargrass subtype.—The beargrass subtype was the most extensive one found in the barrens and it also formed the understory of the open canopy forest. What forest reproduction there was in the burned areas usually occurred on this subtype. Beargrass and low red huckleberry were the predominant species, almost to the exclusion of everything else. This subtype covered large areas in the burns, on the benches under cliffs of the Divide, and on ridgetops.

Mixed subtype.—The mixed subtype was second to the beargrass union in area covered. It was most common on south or west slopes and contained high percentages of forbs, grasses and sedges. The beargrass plants were widely scattered and low red huckleberry as well as the milkvetch of the forb community were absent. Plants common in this subtype were beargrass, yarrow (*Achillea lanulosa*), *Townsendia* sp., bluebunch wheatgrass, *Bromus marginatus*, alpine bluegrass (*Poa alpina*) and sedges (*Carex* spp.).

Forb subtype.—This community had a low growth form and consisted mostly of forbs. A sharp ecotone between it and the beargrass subtype was characteristic. It occurred in scattered patches throughout the beargrass areas and was the major community on talus slopes. The characteristic plant of the forb subtype was a milkvetch (*Astragalus miser*). Other abundant plants were yarrow, dandelion (*Taraxacum* sp.) and in the wetter areas, Siberian chive (*Allium sibericum*).

USE OF VEGETATIVE TYPES

The numbers of elk observed in the various vegetative types are presented in Tables 1 and 2. Their presence, combined with evidences of fresh elk sign in forested areas, indicated certain patterns of vegetative use. During the calving season, in June, the majority of elk utilized the grassland areas at lower elevations, although some use of all vegetative types was noted at

TABLE 2.—PERCENT OF ELK SEEN AND OBSERVER'S TIME SPENT IN VARIOUS VEGETATIVE TYPES DURING THE SUMMERS OF 1957–58

Months	Year	Subalpine Barrens			Subalpine Forest		Lodgepole–Douglas Fir	Grassland	Number of Elk
		Beargrass	Mixed	Forb	Open	Closed			
June	1957	0.2	6.2	6.4	0	0.2	1.0	86.0	471
	1958	1.0	21.2	6.8	1.2	0.2	3.5	66.1	576
July	1957	0.4	7.8	43.8	10.6	1.0	7.6	28.8[1]	801
	1958	3.0	24.0	52.8	10.4	0.3	7.4	2.1[2]	337
August	1957	4.0	47.0	30.0	0	14.0	4.0	1.0	101
	1958	0	1.7	82.6	15.7	0	0	0	121
September	1957	5.7	2.8	5.7	22.9	5.7	8.6	48.6	35
	1958	0	39.3	8.8	21.6	17.6	8.8	3.9	102
Observer's time spent in type	1957		26.0			45.0		29.0	
	1958		35.0			40.0		25.0	

[1] Seen during the first two weeks of July.
[2] Grassland type not covered during the first two weeks of July.

that season. In late June and early July, elk moved through the forest types until by mid-July many were found in the subalpine barrens and along the upper edges of the subalpine forest, where they favored the forb subtype. In late August, there was a downward movement into the forested areas, and by September these types were heavily utilized. All of the harems and sexually active males were seen in the forest types; nevertheless, a few scattered elk had been present in all vegetative types throughout the summer.

The apparent lower level of use of the subalpine barrens during June 1957 as compared to June 1958 (Table 2) was probably the result of severe weather conditions which favored the use of types with cover.

The July grassland data for the 2 years are not strictly comparable (Table 2). The July use of the mixed subtype differed considerably between the 2 years as did the August use of both mixed and forb subtypes (Table 2). This may have reflected the cool and wet July of 1958 (Table 3) which favored prolonged succulence of the forbs. The elk food habit studies of Rouse (1957) and others report a high consumption of grass in the spring and fall but a high forb use during the summer.

The beargrass areas received little use. Although Smith (1930) indicated use of beargrass by Sun River elk under severe winter conditions, and White (1958) reported use of the flowers by deer during summer months, this coarse member of the lily family is poorly suited to be forage. In both burned and unburned regions, beargrass areas appeared similar to the understory of the open-canopy subalpine forest.

TABLE 3.—WEATHER RECORDS[1] FOR JULY AT GIBSON DAM (FIG. 1), ELEVATION 4,590 FEET

Year	PRECIPITATION		TEMPERATURE (degrees F.)	
	Total Inches	Number of Days of Rainfall	Average Maximum	Average Minimum
1957	0.51	5	79.3	45.7
1958	3.66	11	70.8	44.1

[1] Climatological Data, Gibson Dam, Montana. U.S. Weather Bureau LX(7) and LXI(7).

Daubenmire (1952), when writing about the open-canopy subalpine forest, remarked, "The grazier will find the *Picea-Abies/Xerophyllum* habitat type practically worthless either in climax condition or after burning, for the undergrowth dominants are unpalatable and retain dominance by sprouting promptly after burning." This situation appeared to prevail in the present study area and it is considered unlikely that the burned over beargrass areas supported appreciably more elk than its equivalent of unburned subalpine forest. An average of 25 elk per day were seen in the burned habitat as compared with 15 for the unburned areas. This difference probably had little meaning as the elk could be spotted at a much greater range in the burned areas. The average group size was found to be consistently higher for the open areas of grassland and barrens than for the timbered areas. Undoubtedly, much of this differential was due to the poor visibility in forested areas; however, no groups of over 20 were observed in forested areas while groups larger than this were common in open areas. The overall averages for the study were 7.2 elk per group (304 groups) for the open areas and 2.5 (114 groups) in the forested areas. This trait of larger herds in the open was also reported for deer by Dasmann and Taber (1956).

The maximum of 119 elk seen in one summering group is considerably less than the 300 reported by Murie (1951), and the 1,500 reported by Altmann (1956) for the Jackson Hole elk herd in Wyoming.

MIGRATION

During the last week of April 1957, a considerable reduction in the number of elk on the winter range became apparent (Table 4). Some of the elk were observed leaving the winter range by way of a well-used trail, which crossed from one canyon to the next over passes in the upper portions of the drainages bordering the winter range, rather than crossing through the reefs along the Sun River near human habitation. These and other passes also assumed considerable importance in the fall when

TABLE 4.—DISTRIBUTION OF ELK AS INDICATED BY AERIAL AND GROUND OBSERVATIONS

Observations and Dates	Winter Range	Sun River Forks	Summer Range[1]
Aerial counts			
3/1/57	2,000±	350	omitted
4/27/57	500±	900	omitted
11/5–10/57	150	565	tracks along Divide
Number of elk observed during vegetation study			
6/15–30/57	100±	410	60
7/15–31/57	very few	60	500
6/15–30/58	100±	400	170
7/15–31/58	very few	30	300
Ground trend counts			
12/31/57	525	omitted	omitted
3/26/58	1,500±	omitted	omitted

[1] Prairie Reef and the portion of the Continental Divide in the study area.

67 percent of the tag returns was from kills made in the vicinity of passes.

Much of this early movement was into the areas along the North, South and West Forks of the Sun River (Table 4). A summarization of tagging sites, sight relocations and kill sites is presented in Fig. 3. Elk 3 and 4 (Table 5) moved from the winter range to the North Fork during April and May. Elk 2 and 21 (Table 5) moved to the North Fork by June. These observations indicate that the spring elk population of the lower North Fork is composed of animals from the winter range in addition to, presumably, the group of elk which had wintered in the North Fork (Table 4). Four elk (2, 6, 7, 19, Table 5) returned in subsequent years to the same general portion of the North Fork as that where they had been marked as calves. Two marked elk (2, 30, Table 5), observed on the winter range, indicate that calves born on the North Fork do not necessarily winter there.

An aerial survey during the first week of June 1958 showed a few elk present in several areas along the Continental Divide. Movements across the Divide during May in previous years had been reported a number of times by members of the Montana Fish and Game Department (Zajanac and Brandborg, 1948). Considerable sign of movement through the passes of the Divide during the third week of June was noted in both 1957 and 1958, although in 1957, snow deep enough to limit horse travel was present in many areas along the Divide. In June 1958, plant development and snow melt in the high country was an estimated 2 weeks ahead of 1957, and there was little snow remaining. Three marked elk (8, 20, 28, Table 5) were observed in the higher areas along the Divide during the latter half of June 1958.

Calving was observed on the winter range and in the grassland areas of the lower North and West Forks of the Sun River (Fig. 3). A number of elk calves, seen in the high barrens areas of Wrong Creek and Moose Creek during the last half of June, indicated either that calving had occurred in these higher locations or an early movement of calves. Elk calves can move considerable distances. One calf (31, Table 5), marked when a week old by the author, had moved 7 airline miles and across the North Fork of the Sun River when seen the next time 15 days later. Johnson (1951) and Brazda (1953) reported no movements of calves of more than 2 to 3 miles during the first three weeks of June.

The maximum movements during this study were shown by two tag returns (11, 22, Table 5) from the White River in the South Fork of the Flathead drainage, a distance of 28 airline miles from the winter range.

TABLE 5.—TAGGING LOCALITIES FOR 68 ELK AND THEIR RELOCATIONS AS DETERMINED BY SIGHT RECORDS OR KILLS (FIG. 3). (ELEVATION OF THE WINTER RANGE IS 5,000 FEET; AND TAGGING LOCATIONS ON THE NORTH FORK, SUN RIVER, WERE AT 5,100 FEET.)

No.	Sex	Date and Locality of Tagging	Locality, Elevation, and Date of Relocations	Miles from Tagging Location
1	F	Winter range, 1/57	N. of W.F. Sun River, 7,200 ft., 7/57;	19
			killed near winter range, 5,100 ft., 12/57	2
2	F	N.F. Sun River, 6/48	Winter range, 5,100 ft., 2/57, recapture;	14
			N.F. Sun River, 5,100 ft., 6/57	14
3	F	Winter range, 2/57	Winter range, 5,000 ft., 4/4/57;	0
			N.F. Sun River, 5,100 ft., 5/28/57;	18
			N.F. Sun River, 5,400 ft., 6/57	20
4	F	Winter range, 2/57	Winter range, 5,000 ft., 5/8/57;	0
			N.F. Sun River, 5,100 ft., 5/28/57;	14
			N. of W.F. Sun River, 7,600 ft., 7/58	19
5	F	Winter range, 3/57	Divide near head of Spotted Bear River, 7,200 ft., 7/57;	27
			winter range, 5,000 ft., 1/58;	0
			divide near head of Spotted Bear River, 7,200 ft., 7/58	27
6	F	N.F. Sun River, 5/57	N.F. Sun River, 5,200 ft., 6/58;	7
			killed–N.F. Sun River, 5,100 ft., 11/58	3
7	M	N.F. Sun River, 5/57	Divide near head of Spotted Bear River, 7,500 ft., 7/57;	11
			N.F. Sun River, 5,200 ft., 6/58	5
8	F	Winter range, 2/58	Moose Creek, 7,000 ft., 6/58;	25
			Moose Creek, 7,000 ft., 8/58;	25
			killed–s. Gibson Lake, 6,000 ft., 11/58	6
9	M	Winter range, 4/58	N. of W.F. Sun River, 7,800 ft., 7/58;	20
			N. of W.F. Sun River, 7,800 ft., 8/58	19
10	F	Winter range, 1/57	N. of W.F. Sun River, 7,000 ft., 7/57	19
11	F	Winter range, 2/57	Killed–White River, 6,000 ft., 10/57	28
12	M	Winter range, 2/57	Killed–6 miles s.w. winter range, 6,000 ft., 11/57	6
13	F	Winter range, 3/57	Winter range, 5,000 ft., 3/58	0
14	F	Winter range, 3/57	Winter range, 5,000 ft., 12/57	0
15	F	Winter range, 4/57	Killed winter range, 5,000 ft., 10/57	0
16	F	Winter range, 4/57	Winter range, 5,000 ft., 3/58	0
17	F	Winter range, 2/57	Winter range, 5,000 ft., 3/58	0
18	F	Winter range, 1/57	Winter range, 5,000 ft., 3/58	0
19	F	N.F. Sun River, 6/56	N.F. Sun River, 5,200 ft., 6/57	6
20	M	Winter range, 2/58	Moose Creek, 7,000 ft., 6/58	25
21	F	Winter range, 2/58	N.F. Sun River, 5,200 ft., 6/58	16
22	F	Winter range, 2/58	Killed White River, 6,000 ft., 10/58	28
23–24	F	Winter range, 2/58	Killed–2 miles s.w. winter range, 6,000 ft., 11/58	2
25	F	Winter range, —	Killed–w. Continental Divide, 6,400 ft., 10/58	26
26–27	F	Winter range, 2/57	N. of W.F. Sun River, 7,400 ft., 7/57	19
28	F	Winter range, —	Wrong Creek, 6,600 ft., 6/58	27
29	—	N.F. Sun River, 6/58	Killed–N.F. Sun River, 5,200 ft., 11/58	1
30	M	N.F. Sun River, 5/56	Winter range, 5,000 ft., 4/58	14
31	M	N.F. Sun River, 6/58	N.F. Sun River, 5,200 ft., 6/58	7
32–35	M & F	Winter range, '57, '58	Killed–2 miles w. of winter range, 6,000 ft., 11 and 12/57 and '58	2
36–51	M & F	Winter range, '57, '58 and 3 before 1957	Killed–3 miles or less s. of Gibson Lake 6,000 ft., 11 and 12/57 and '58	4–12
52–57	M & F	Winter range, '57, '58 and 1 before 1957	Killed–6 miles s. of Gibson Lake 6,000 ft., 11 and 12/57 and '58	4–12
58–68	M & F	Winter range, '57, '58 and 3 before 1957	Killed–N.F. Sun River, 6,000 ft., 10 and 11/57 and '58	11–12

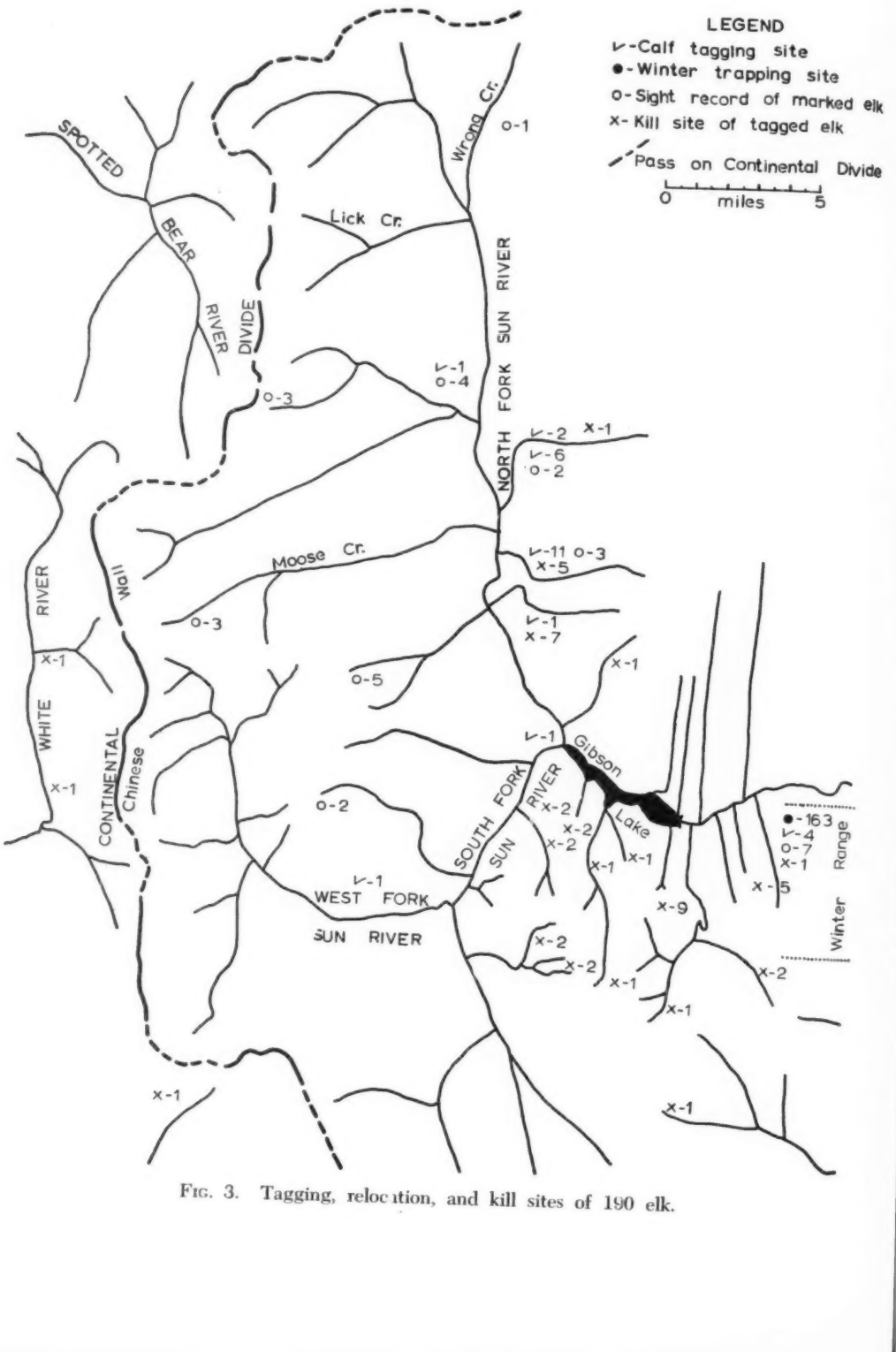

FIG. 3. Tagging, relocation, and kill sites of 190 elk.

TABLE 6.—ELK MOVEMENT THROUGH PASSES OF THE CONTINENTAL DIVIDE IN THE STUDY AREA FOLLOWING THE OPENING OF HUNTING SEASONS ON THE WEST SLOPE

Observations	1957	1958[1]
INDEX OF HUNTING PRESSURE		
Number of hunters in the 18-sq. mile White River Basin	12	4
PASSES CHECKED		
Open to hunting on west slope	2	4
Number of elk that crossed pass after season opened[2]	3 to east, 1 to west	12 to east, 5 to west
Closed to hunting on both slopes		4
Number of elk that crossed pass after season opened[3]	—	1 to east, 5 to west
AERIAL SURVEYS		
Number of fresh game trails crossing Divide, Oct. 9, 1957	18	—
Number of fresh game trails crossing Divide, Nov. 5, 1957	9	—

[1] Data in this column from Janson (1958).
[2] During the first two days of the season.
[3] During the first three days of the season.

One animal (5, Table 5) was observed in the same township and section during July of both years. This animal and five others (13, 14, 16, 17, 18, Table 5) also returned to the same winter range in consecutive years. Elk 8 and 9 (Table 5) were observed twice in the same locality during a summer.

An attempt was made to evaluate the hypothesis that an early fall hunting season on the west side of the Divide induced migration into the Sun River Game Preserve on the east side of the Divide. Major pass areas were checked for tracks in both 1957 and 1958, and throughout both summers, small groups of elk were observed crossing the Divide in both directions. The season opened on September 15, both years, and hunting was allowed on the west slope of the Divide except for the portion of the Spotted Bear drainage immediately west of the Lick Creek passes (Fig. 3) which was closed in 1958.

The aerial surveys (Table 6) were made immediately after fresh snowfalls; and to avoid considering mountain goat trails, only long trails, continuous on both sides of the Divide, were counted. Three of the October 9 trails and one of the November 5 trails were through the passes of the White River basin. The last hunters were reported to have left the basin on October 17.

The data in Table 6 seem to indicate that the hunting in the early season did not have any appreciable effect on elk migration.

SUMMARY

A study of summer use of vegetative types and migration of the Sun River elk herd in Montana was conducted during 1957 and 1958. Of a total of 190 elk tagged and marked, 68 were relocated one to three times. Discussion of the usage of vegetative types was based upon observations of 2,544 elk seen during the summers of 1957 and 1958.

Five vegetative types and three subtypes were recognized in the study area. During June the grassland areas were the most heavily used type. Movement through the forest types to the subalpine barrens was noted in June and July. The forb subtype was most heavily used in the subalpine barrens, followed by the mixed subtype. The beargrass subtype, covering half of a study area in the barrens, was little used. In late summer, elk moved downward into the forest types.

Groups seen in open areas and in forest types averaged 7.2 and 2.5 elk, respectively.

Migration from the winter range to the North Fork of the Sun River occurred in April and May. The grassland areas of the lower North Fork drainage were used as a calving ground.

Checks for movement through the passes of the Continental Divide indicated that a September hunting season on the west side of the Divide did not induce any appreci-

able movement of elk into the Sun River Game Preserve on the east side.

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RELATION OF ECTOPARASITE POPULATIONS TO RABBIT POPULATIONS IN NORTHERN ILLINOIS

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This report deals with the relationship of ectoparasite populations to rabbit (*Sylvilagus floridanus mearnsi*) populations and distribution on two areas in Lee County, Illinois, between 1951 and 1954. A previous paper (Stannard and Pietsch, 1958) reports only the kinds and numbers of ectoparasites found. These are contributions from Illinois Federal Aid Project No. 42-R, the Illinois Department of Conservation, the United States Bureau of Sport Fisheries and Wildlife, and the Illinois Natural History Survey.

The field work was accomplished by Lysle R. Pietsch, formerly project leader, and identifications of ectoparasites were made by Lewis J. Stannard, Illinois Natural History Survey. The data pertaining to size of the rabbit population were analyzed by the junior author, and those pertaining to the ectoparasite population by the senior author.

LOCATION AND METHODS

Lee County is typical of a large section of

the Midwest in which farming is intensive and much of the woodland heavily pastured. At the time of study, only 3 percent of the county was in woodland of any kind, of which four-fifths was pastured and unfavorable to the bird and rabbit tick (*Haemaphysalis leporis-palustris*). The woodland is, for the most part, widely dispersed; one of the larger unpastured units is the long line of trees and brush bordering the Green River. Farmsteads are one of the more important rabbit habitats in such areas in winter.

The two study areas, of 1 square mile each, are bisected by the Green River whose course totals approximately 1.4 linear miles in each. The land on both sides is gently rolling.

When the study was made, each area had four farm houses with outbuildings. Six or seven small brushy wooded areas, independent of the line bordering the river, made up 16.1 percent of Area 1, and three or four wooded areas made up 14.5 percent of Area 2. Area 1 had two gravel pits, both partly filled with water and surrounded by spoil piles grown over with brush, near the Green River.

Area 1 included about 1 mile more of fence row and 0.5 mile more of grassy or brushy waterway than Area 2. Approximately equal amounts of each area were under cultivation; in 1953, 80 percent of Area 1 and 78 percent of Area 2 were in grain (mainly corn, oats and soybeans) and 13 and 8 percent respectively in hay crops.

TABLE 1.—TRAPPING AND HUNTING DATA

	Year	NUMBER PER YEAR	
		Area 1	Area 2
Trap-nights	1952	3,938	2,313
	1953	2,115	2,115
	1954	1,465	1,465
	Total	7,518	5,893
Rabbits per 100 trap-nights	1952	6.1	2.9
	1953	4.0	4.5
	1954	10.3	3.6
	Mean	6.8	3.7
Rabbits harvested	1952–53	44	28
	1953–54	78	69
	1954–55	95	74
	Mean	72	57
Gun-hours	1952	116	117
	1953	200	246
	1954	190	239
	Mean	169	201
Rabbits per gun-hour	1952	0.38	0.24
	1953	0.39	0.28
	1954	0.50	0.31
	Mean	0.42	0.22

A check of hunter success (Table 1) was made in each of the 3 years by examining hunters' bags and recording the numbers of hours spent hunting. A schedule of summer, fall, and late-winter trapping was followed.

Live traps were set at permanent trap stations on the two study areas. Because most of the land was cultivated, the trap stations were restricted to fence rows, drainage gullies, uncultivated corners, and woodlots.

The ratio of marked to unmarked rabbits, found by retrapping and by an examination

TABLE 2.—ESTIMATES OF THE SIZE OF RABBIT POPULATIONS ON AREA 1

Basis of Calculation	Year	BASED ON RETRAPPING IN THE MONTHS OF:												Based on Hunter Bag, November	Annual Mean
		J	F	M	A	M	J	J	A	S	O	N	D		
Register (calendar) method	1952	46	38	39	48	46	70	120	203	212	170	130	75		100
	1953	74	66	29	66	118	142	148	160	160	160	125	60		109
	1954	60	60	22	36	57	80	107	107	108	106	65	—		68
	Mean	60	55	30	50	74	97	125	157	160	146	107	—		92
Ratio of marked to unmarked rabbits	1952	42 (17.2)[1]					150 (164.4)				253 (44.2)			370 (77.5)	
	1953	113 (32.9)						740 (293.8)			278 (52.5)			415 (75.0)	
	1954	185 (72.2)									266 (48.4)			414 (71.1)	
	Mean													400	

[1] Standard error in parentheses.

TABLE 3.—ESTIMATES OF THE SIZE OF RABBIT POPULATIONS ON AREA 2

Basis of Calculation	Year	Based on Retrapping in the Months of: J	F	M	A	M	J	J	A	S	O	N	D	Based on Hunter Bag, November	Annual Mean
Register (calendar) method	1952	22	21	20	22	40	44	42	78	78	78	62	42		46
	1953	44	44	15	25	32	54	65	79	79	79	60	26		50
	1954	25	25	10	20	26	52	38	40	35	35	32	—		34
	Mean	31	30	15	33	33	50	48	66	64	64	51	—		41
Ratio of marked to unmarked rabbits	1952						39 (23.0)				239 (88.9)			355 (237.0)	
	1953	122 (73.2)[1]						150 (63.0)			396 (26.4)			382 (73.9)	
	1954	158 (74.1)									—	—		481 (188.2)	
	Mean													406	

[1] Standard error in parentheses.

of hunters' bags, was used to estimate the size of the populations. Relative populations were calculated by means of the register (calendar) method (Tables 2 and 3). This method is based on the assumption that any rabbit caught was either present on the area during its entire life or that shifting of populations to the area was offset by an essentially equal shifting from the area. This method adds considerably to the volume of data available for calculation of the population.

Locations at which rabbits or rabbit signs were seen when cruising were recorded on maps and later analyzed for degree of concentration. The maps were divided into plots 250 feet on a side and the percentage of plots in which rabbits had been seen during cruising periods was calculated.

Ectoparasites were removed from rabbits in the field by immobilizing the host and searching and combing its upper or free side. Up to 25 of each species of ectoparasite were taken from each rabbit examined. If fewer than 25 of each species were found on one side, the other side was searched. When the number of each ectoparasite was greater than 25, the remaining number usually was estimated based on the number taken from the exposed side of the rabbit. (In 11 cases for Area 1, one-half, and in 4 cases, one-fifth of the population was estimated).

For Area 1 this procedure resulted in a complete count of ectoparasites in January, February and November, and with one exception (114 fleas in February), a complete count of fleas during all other months; and a partial count, plus estimate, of ticks from May through October. For Area 2, the method resulted in a complete count of ectoparasites.

Comparison of the populations of ectoparasites on the two areas was based on those months (Jan., Feb., June, July, Oct., and Nov.) for which there were paired data. Since some ectoparasites undoubtedly were missed, the results are regarded as minimum and comparative.

OBSERVATIONS

Rabbit Populations

In order to compare rabbit populations on the two areas, it is convenient to examine the means for the 3-year period (Tables 2 and 3). Those based on the ratio of unmarked to marked rabbits in hunter bags most nearly indicate the real populations. The means are 400 ± 76.2 for Area 1 and 406 ± 168.5 for Area 2.

The means for other methods were as follows on 1 and 2 respectively: rabbits harvested, 72 and 57; rabbits per gun hour, 0.42 and 0.22; rabbits per 100 trap nights, 6.8 and 3.7 (Table 1); and annual mean based on the register method, 92 and 41 (Tables 2 and 3).

Rabbits were observed 120 times on Area 1 and 71 times on Area 2 in 25 cruising periods on each. The average distance between nearest points on Area 1 was about

11.3 yards and that on Area 2 was about 16.5 yards.

Of the 250-foot plots on Area 1, 23 percent were in use over the 3-year period and 17 percent of those in Area 2. This is an approximate measure of the percentage of each area occupied by rabbits.

Adjoining sides of plots in which rabbits had been seen were counted. There were 50 on Area 1 and 19 on Area 2, indicating that the opportunity for contact between rabbits on Area 1 was about 2.6 times as great as that on Area 2.

Ectoparasite Populations

Two common species of rabbit ectoparasites were found: the bird and rabbit tick and the common rabbit flea (*Cediopsylla simplex*).

A few rabbits were infested by the variable wood tick (*Dermacentor variabilis*), the Eastern rabbit tick (*Ixodes dentatus*), the many-spined rabbit flea (*Odontopsyllus multispinosus*), and several ectoparasites of other species (Stannard and Pietsch, 1958).

Bird and rabbit tick on Area 1.—Adults of the bird and rabbit tick, a hibernating stage, were found regularly on rabbits from the middle of February until August 20 (Table 4). Twelve percent of the rabbits handled during the last 2 weeks of February were infested, and the percentage of infestation increased until, in April and May, 100 percent were infested. After May, the rate declined and the last adults were observed on rabbits in November.

Nymphs, also a hibernating stage, appeared on rabbits in March. In April, 100 percent of the rabbits examined were infested; the rate of infestation then declined to about 17 percent in July, increased again to 73 percent during the first of September, and declined gradually to 0 percent by December 1. The decline beginning in April and ending in July was due partly to transformation of nymphs to the adult stage and partly to natural death rate.

Larvae of the bird and rabbit tick were first observed during the third week in June. A mid-season decline occurred about the end of July, and increase followed about the first of August. By the last week in September, 66 percent of the rabbits were infested, after which infestation declined slowly. Larvae were last observed on rabbits during the third week in November. Sixty-three rabbits examined during the first week in November were without larvae and

TABLE 4.—POPULATIONS OF BIRD AND RABBIT TICKS (*Haemaphysalis leporis-palustris*) ON RABBITS ON AREA 1

Dates	Number of Rabbits Examined	Percent of Rabbits Infested			Average Number Per Infested Rabbit		
		Adults	Larvae	Nymphs	Adults	Larvae	Nymphs
Jan.*	6	0	0	0	0	0	0
Feb.* 1–15	32	0	0	0	0	0	0
Feb.* 16–27	85	12	0	0	2.3	0	0
Mar.	11	87	0	87	17	0	15
Apr.	3	100	0	100	39	0	4.3
May*	2	100	0	50	26	0	2.0
June* 1–15	16	69	0	38	3.4	0	1.8
June 16–30	26	77	62	31	10	53	7.0
July	42	45	0	17	7.9	0	2.5
Aug.	9	67	44	33	2.0	101	13
Sept. 1–15	4	0	50	50	0	71	25
Sept. 16–30	30	0	66	73	0	41	16
Oct.*	82	0	23	49	0	6.6	61
Nov.*	63	1.5	3	37	1.0	1.0	2.9
Dec.	8	0	0	0	0	0	0
Mean	—	47	21	47	7.2	18	10

* Months for which data are available for both areas.

only two larvae were found on five rabbits examined during the last 3 weeks of November. The 10th of that month was the last date when any considerable number of larvae were observed.

Populations of bird and rabbit ticks were studied on Area 2 only in June, July, October, and November. Adults infested 9 out of 15 rabbits examined in June and 7 of 31 examined in July. None was found on six rabbits examined in August. The average number per infested rabbit was never large: only 5.1 in June and 3.0 in July.

Nymphs infested 2 of the 15 rabbits examined in June, 3 of the 31 examined in July, 3 of the 6 examined in August, and 13 of the 37 examined in early November. The number of nymphs per infested rabbit was low: from 1 to 3 in July and August except in one case of 17 on 1 rabbit; and 1 to 2 in October and November except for 1 rabbit which bore 6.

Larvae infested 1 of the rabbits in July, 3 in August and 7 of the 37 rabbits in November. The number of larvae did not exceed 3 per infested rabbit.

Comparison of tick populations.—There were larger populations of the bird and rabbit tick in Area 1 than in Area 2. The rabbits on Area 1 also were more frequently infested; in June, from 69 to 77 percent on Area 1 bore adult ticks, while 60 percent of those on Area 2 bore them; in July when 45 percent on Area 1 bore them, only 23 percent on Area 2 were infested, and in late October and early November, from 37 to 49 percent in Area 1 bore nymphs, but only from 15 to 36 percent in Area 2 bore them. About 2.1 times as many were infested on Area 1. No ticks were found on 51 rabbits examined on Area 2 during January and February. However, in November, when only 3 percent in Area 1 bore larvae, 19 percent (of 37 examined) bore them in Area 2.

The mean number of ticks per infested rabbit, a less sensitive index to infestation, also was higher on Area 1 than on Area 2.

Common rabbit flea.—Adult fleas were present on rabbits throughout the year. Larvae and pupae, which occur in nests and on the ground, were not studied.

On Area 1, from which data are available for every month, the prevalence of infestation of rabbits was lowest during June (44 percent) and highest (from 83 to 100 percent) during winter and spring (Table 5). The average number of fleas per infested rabbit was lowest (1.5) about August and highest (68) in May.

Data from Area 2 were more extensive

TABLE 5.—POPULATIONS OF COMMON RABBIT FLEAS (*Cediopsylla simplex*) ON RABBITS ON BOTH AREAS

Dates	Number of Rabbits Examined		Percent of Rabbits Infested		Average Number Per Infested Rabbit	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
Jan.	6	2	83	100	6.0	3.5
Feb. 1–15	32	46	100	56	5.7	4.9
Feb. 16–27	85	0	85	—	7.9	—
Mar.	11	0	100	—	29	—
Apr.	3	0	100	—	27	—
May	2	0	100	—	68	—
June 1–15	16	15	69	53	5.7	3.3
June 16–30	26	0	44	—	7.7	—
July	42	28	50	57	4.0	2.7
Aug.	9	6	59	0	1.5	—
Sept. 1–15	48	0	50	—	3.8	—
Sept. 16–30	30	0	57	—	13	—
Oct.	82	34	65	56	5.4	3.2
Nov.	68	37	90	95	4.0	3.2
Dec.	8	0	100	—	45	—
Mean for months in common	—	—	74	60	4.7	3.4

in February, June, July, October, and November. In February about 56 percent of the rabbits were infested, in June 53 percent, in October 56 percent, and November 95 percent. The average numbers of fleas per infested rabbit varied from 2.7 to 4.9.

Comparison of flea populations.—Area 1 had a considerably larger population of rabbit fleas than did Area 2. Direct comparison may be made only for those months in which samples were taken in both areas. The mean prevalence of infestation and average number of fleas per infested animal based on these months were: 74 percent and 4.7 on Area 1, and 60 percent and 3.4 on Area 2. (The mean prevalence of infestation for Area 1 for the year was about 77 percent.)

DISCUSSION

Rabbit populations.—We assume that the reader is acquainted with assumptions inherent in the methods of estimating populations based on trapping, marking, and releasing animals. Because the trapping for this study was done in parts of the area known to be inhabited by rabbits, rather than uniformly over the whole area, the estimates based on retrapping represent mainly the population on the area influenced by the traps; some rabbits undoubtedly were missed. Also, rabbits that avoid traps or those that are prone to enter them, produce further underestimates of the true population. The estimates based on trap-retrap data, calculated by the register method, therefore are relative and minimum. The mean population for November based on this method was 107 for Area 1 and 51 for Area 2. That for Area 1 was 2.1 times that of Area 2.

Estimates based on the proportion marked in the hunter's bag are likely to approximate more nearly the true populations on the area since they are not affected by trap-shy rabbits. However, they are reliable only to the extent that the size of the sample is adequate. The estimated means of populations based on this method for November are 400 for Area 1 and 406 for Area 2. Statistical evaluation indicates that the populations might have been between 326 and 474 rabbits on Area 1 and between 240 and 570 on Area 2, or from about 4 to 10 times as great as estimates based on trapping, marking, and retrapping.

Other data consistently indicate that the population on Area 1 was greater than on Area 2 by the following proportions: total rabbits harvested—1.3, rabbits per gun hour—1.9, rabbits per 100 trap nights—1.8, mean annual population based on the register method—2.2, times rabbits were observed—1.7, average distance between points of observation—1.5, number of map-squares used by rabbits—1.4. The mean of these is 1.7.

Ectoparasite populations.—The bird and rabbit tick is an ubiquitous species occurring in Alaska, Canada, the United States, Mexico, Panama, and Argentine (Cooley, 1946:35). Larvae and nymphs depend largely for sustenance on rabbits and ground-inhabiting birds, and adults depend on rabbits (Joyce and Eddy, 1943). Undoubtedly the size of bird and rabbit tick populations depends in part on the size of combined populations of ground-inhabiting birds and rabbits as well as on habitat, climate, weather, and season. Although a large population of ticks one year tends to assure a large population the next, the size of the current host population is important (Green, *et al.*, 1943).

In Area 1, there was a larger population of bird and rabbit ticks than in Area 2, and the rabbits on it also were more frequently infested; during summer about 2.1 times as many rabbits were infested on Area 1 as on Area 2.

There also was a larger population of rabbit fleas on Area 1 than on Area 2. Direct comparison may be made only for those months in which samples were taken in both areas. The mean percentage of rabbits infested on Area 1, based on these months, was 1.2 times as large as that on Area 2 and the average number of fleas per infested rabbit was 1.6 times as large. If the rabbit population was only 1.5 times as large on Area 1 as on Area 2, then the flea population on the rabbits was almost 3 times as large;

and if the rabbit population was twice as large, the flea population was about 3.8 times as large.

These data support those of other studies (Hirst, 1927; and Eskey, 1930) which show that the size of ectoparasite populations generally is related positively to the size of their host populations. When compared to data in studies by Green, *et al.* (1943), and Joyce and Eddy (1943), they also suggest that there is a marked relation between ectoparasite populations, and size and dispersion of suitable habitats; widely scattered, small habitats support decidedly lower concentrations of ectoparasites than large ones. Any study of infestation by ectoparasites or transmission of disease by them should therefore take into account the size and dispersion as well as quality of habitats along with the size of the host population.

In Tama County, Iowa, about 160 miles west of Lee County, Illinois, Joyce and Eddy (1943) found the following average number of ticks per cottontail rabbit: 24 in April, 24 in May, 24 in June, 20 in July, 122 in August, 49 in September, 76 in October, 2.2 in November, and 0 in December. The authors offered no comment on the size of the rabbit population but noted that the area studied was, "comprised mostly of rather rough terrain along the Iowa River," that a large part was timber or brush land with "several" cultivated fields, and that it was very good habitat for birds. This implies that the Iowa area was more uniformly suitable to cottontail rabbits than either of our Illinois areas and indicates that the cottontail population was larger. The infestation by ticks in Iowa appears to have been slightly higher than those found on Area 1, the better of the two in Illinois.

In Minnesota, where the snowshoe hare (*Lepus americanus*) population per square mile was estimated by the trap-retrap method to vary from levels as high as 319 in May to 623 in September (larger than the Illinois cottontail population which was, say, 400 in November), the tick population on the hares averaged from 505 in May to 3,777 in August (Green, *et al.*, 1943). Since there were only one-fourth as many ticks on cottontail rabbits in Minnesota as on snowshoe hares in the same area, this would indicate from 125 to 944 ticks per cottontail, as compared to 28 on rabbits in May and 116 in August on Area 1 in Illinois: from 4.4 to 8.1 times more ticks in Minnesota. The Minnesota area was more uniformly suitable to hosts than were our Illinois areas.

The continuity of habitat in the several areas therefore ranged from poor to good for the hosts, and the populations of the bird and rabbit tick were progressively larger as follows: Illinois Area 2, Illinois Area 1, Iowa area, and Minnesota area.

SUMMARY AND CONCLUSIONS

A study was made of populations of cottontail rabbits and their ectoparasites on two areas in northern Illinois. Rabbits were live-trapped, marked and released for future observation and live-trapping.

The number taken per trap-night was 1.8 times larger on Area 1 (based on 7,518 trap-nights) than on Area 2 (5,893 trap-nights). Over the 3-year period, 1.3 times as many rabbits were bagged by hunters on Area 1 as on Area 2, a figure based on 169 and 201 gun-hours respectively. The number bagged was larger in each of the 3 years on Area 1. The number of rabbits taken per gun-hour was 1.9 times larger on Area 1 than on Area 2.

Estimates were made of the relative population of rabbits by means of the register (calendar) method. During each of the 3 years, the population on Area 1 was calculated to be slightly more than twice as large as that on Area 2. The mean of the calculations for the 3-year period was 2.2 times as great for Area 1 as for Area 2.

An attempt was made to determine the absolute or real population of rabbits on each area in November by means of the ratio of marked to unmarked rabbits in the hunter bag. The mean for the 3-year period on Area 1 was 400 and that for Area 2 was 406. Contrary to the preceding estimates, these means indicate no difference. However, the samples upon which they were based were small: the standard error for

Area 2, for example, varied from 19 percent to 67 percent of the estimated population per year.

In 25 paired cruising periods in winter and summer, rabbits were seen 1.7 times as often on Area 1 as on Area 2. The average distance between nearest points of observations was 11.3 yards on Area 1 and 16.5 yards on Area 2. Rabbits or their signs were observed 1.4 times as often on Area 1 as on Area 2.

On these bases, we believe that the population on Area 1 was at least 1.5 times as great on Area 1 as on Area 2 and that it might have been twice as great. This is strongly indicated by the annual means (92 and 41) resulting from use of the register method which most efficiently uses the population data and by the consistency of all methods in indicating the larger population on Area 1.

In general, the percentage of infestation on rabbits by the bird and rabbit tick on Area 1 was 2.1 times larger than that on Area 2 and the percentage of infestation by the common rabbit flea was 1.2 times larger. The average number of fleas per infested rabbit was about 1.4 times larger on Area 1. Data on the average number of ticks are too limited to determine the average.

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OVARIAN CHARACTERISTICS IN ELK OF KNOWN BREEDING HISTORY

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Big game managers who wish to determine the productivity of ungulates by counting embryos, generally have difficulty obtaining an adequate sample during the gestation period. Some deer managers have partially overcome this problem by using Cheatum's (1949) technique for ovarian analysis in the larger numbers of does available for study in the autumn hunter harvest.

In this technique, the ovulation rate of the current breeding season is determined by a count of corpora lutea; the ovulation rate of the prior season is determined by a count of corpora albicantia, or pigmented scars, which develop from corpora lutea of pregnancy following parturition. Cheatum stated that in white-tailed deer (*Odocoileus virginianus*) the only ovarian structure which commonly becomes pigmented is the corpus luteum of pregnancy. He assumed that corpora albicantia would persist through the hunting season following parturition. The fertilization rate is computed by first determining the ratio between corpora lutea and embryos in does collected during gestation. This ratio is then applied to the number of corpora lutea or corpora albicantia in ovaries collected in the hunting season. It is assumed that at each estrus at least one ovum is fertilized, so practically

every doe with corpora lutea can be considered impregnated. This technique has been used not only for white-tailed deer (Cheatum and Severinghaus, 1950), but also for Columbian black-tailed deer (*O. hemionus columbianus*) (Taber, 1953) and mule deer (*O. h. hemionus*) (Robinette, *et al.*, 1955).

Ovarian analysis has also been used for determining elk productivity. Cheatum and Gaab (1952) examined 224 pairs of elk ovaries from Yellowstone Park to learn if the technique was applicable to elk, and deduced that a better knowledge of elk ovarian morphology was necessary to evaluate pigmented scars. In Utah, studies of the Nebo elk herd (Rognrud, 1953) and the Cache elk herd (Hancock, 1955) included ovarian analysis. Burt and Gates (1959) examined ovaries of the Pecos elk herd in New Mexico. Halazon and Buechner (1956) described the incidence of secondary ovulation and development of multiple corpora lutea in elk.

In a study conducted to obtain and describe known-age elk (*Cervus canadensis nelsoni*) embryos (Morrison, *et al.*, 1959), there was an opportunity to correlate elk ovarian morphology with known breeding history. Graafian follicles, corpora lutea, and corpora albicantia were measured and described so that any characteristics which could be used to interpret productivity would be understood as well as possible. The information obtained concerning elk ovarian characteristics is presented here.

This article is based on part of a master's thesis submitted to Montana State University. John J. Craighead and Philip L. Wright contributed greatly to the study, which was a project of the Montana Cooperative Wildlife Research Unit. Much valuable assistance in the field work was given by the U.S. Fish and Wildlife Service employees of the National Bison Range, Moiese, Montana, under the supervision of John E. Schwartz, and by personnel of the Montana Fish and Game Department. E. L. Cheatum, George Halazon, and Charles Trainer worked to initiate the study.

METHODS AND MATERIALS

The elk used and study methods have been described in detail previously (Morrison, *et al.*, 1959); a brief review is given here. Groups of individually marked wild cow elk were confined at the National Bison Range during the breeding seasons of 1954, 1955, and 1956. During each season, a mature bull was released into the cow pen during daylight and removed at night, and the group was constantly observed when the bull was present. Use of a vasectomized bull in the early part of the season permitted recurrence of estrus; a normal bull was used in the latter part of the season to fertilize the cows. They were fed native grass hay and 20 percent protein ruminant cubes.

Some of the cows which failed to copulate were sacrificed when the annual observation period ended in December; others were retained in a holding pasture for use in the following year. Cows which copulated were sacrificed at intervals throughout the gestation period. Additional reproductive tracts were obtained from free-ranging cows killed in the Bison Range herd reduction each winter. Twenty pairs of ovaries from gravid elk and 24 pairs from nongravid elk were obtained. All of the nongravid elk were observed in the study groups. Ten of the gravid elk were shot on the open range, and 10 were observed to breed in the study pens. All ovaries were fixed in AFA or 10 percent formalin at the time of sacrifice, and later stored in 70 percent alcohol.

Primary analysis consisted of measuring and weighing the ovaries and describing the surface appearance. Secondary analysis was devoted to slicing the ovaries into sections from approximately 1 to 2 millimeters thick. All internal structures were measured and described. If a section lacked noticeable structures but appeared to have an ovulation scar on the surface, it was sliced again. Many small pigmented scars were located in this manner. Final analysis was accomplished by microscopic examination of selected portions of the ovaries. Such portions were sectioned at 10 microns and differentially stained with Groat's quadruple stain.

TABLE 1.—AVERAGE NUMBER OF GRAAFIAN FOLLICLES PER PAIR OF OVARIES ACCORDING TO DIAMETER CLASS AND REPRODUCTIVE STATUS

Reproductive Status	Number of Elk	Average Number of Follicles per Pair of Ovaries	Diameter Class of Follicles		
			2 to <5 mm.	5 to <8 mm.	8 and 8+ mm.
Gravid	20	20.5	19.0	1.0	0.5
Nongravid	24	16.5	15.2	0.8	0.5

FINDINGS

Graafian Follicles

Nutritional and psychological conditions are known to affect ova production in many species of vertebrates. Ovaries obtained in this study came from groups of elk cows living in different circumstances. Some were free-ranging and undisturbed; other groups were kept in different conditions of confinement. The cows differed in age and physical condition, factors which may influence the development of Graafian follicles.

Graafian follicles were measured and counted to learn if a correlation between follicular development and the reproductive performance of the cows could be shown. For a uniform comparison of follicular development, no follicle less than 2 by 2 millimeters in any two diameters at right angles to each other was counted. When tabulated according to average diameter, the numbers of follicles present formed peaks of abundance in three size groups: less than 5 mm.; 5 mm. to less than 8 mm.; 8 mm. and over. The average number of follicles in each size group is listed in Table 1, and a comparison is made between gravid and nongravid elk. There does not appear to be a major difference in follicle numbers between gravid and nongravid elk. Since these averages were based on the entire group irrespective of sacrifice dates or the age of the individual cows, averages were computed to learn if the number of follicles varied in relation to these factors.

The only sample of ovaries obtained over a long period of time was from gravid elk sacrificed during the gestation period. The numbers of follicles in this sample are listed in Table 2. If the samples are representative, it appears that a reduction in the number of larger follicles occurred as gestation progressed. Halazon and Buechner (1956) found that ovaries from anestrous elk lack follicles larger than 2 mm.

The average number of follicles in elk of each age group is presented in Table 3. As compared to gravid yearling cows, the number of follicles increase at 2 years and decreased after 6 years. The two gravid yearling cows were shot in the Bison Range herd reduction in 1956. Conception in yearling elk has been described by Murie (1951) as rare; a few occurrences of this have earned mention in the literature (Coffin and Remington, 1953; Saunders, 1955; Hancock, 1955). In the Blue Mountains in southeastern Washington, Buechner and Swanson (1955) found that 54 percent of 35 yearling cow elk were pregnant.

To determine if confinement may have adversely influenced fecundity, a compari-

TABLE 2.—AVERAGE NUMBER OF FOLLICLES PER PAIR OF OVARIES ACCORDING TO DIAMETER CLASS AND STAGE OF GESTATION

Days of Gestation	Number of Elk	Average Number of Follicles per Pair of Ovaries	Diameter Class of Follicles		
			2 to <5 mm.	5 to <8 mm.	8 and 8+ mm.
0– 60	9	22.5	20.5	1.4	0.6
61–120	7	18.5	17.3	0.9	0.3
121–180	3	17.9	17.0	0.3	0.6
247	1	23.0	23.0	—	—

TABLE 3.—AVERAGE NUMBER OF FOLLICLES PER PAIR OF OVARIES ACCORDING TO AGE AND REPRODUCTIVE STATUS

GRAVID			NONGRAVID		
Ages	Number of Elk	Average Number of Follicles Larger than 2 × 2 mm.	Ages	Number of Elk	Average Number of Follicles Larger than 2 × 2 mm.
1	2	18.5	1	1	11.0
2	1	32.0	2	4	25.0
3	7	20.0	3	3	26.3
4–6	6	23.0	4–6	4	17.0
7–10+	3	13.5	7–10+	12	11.3

son was made between follicular development in free-ranging elk and various groups of penned elk (Table 4). Application of the "t" test disclosed that only the 1955 study elk differed significantly in numbers of follicles from the free-ranging elk. All cows in the 1955 study herd and several cows in the 1954 and 1956 study herds failed to show estrus. In 1955, the elk did not learn to eat ruminant pellets until late in the study period, and a low grade alfalfa was the only food available for several weeks. Their physical condition deteriorated noticeably until native grass hay was provided and they commenced eating ruminant cubes. Considerable disturbance near the pen kept them constantly alarmed. Five of them were over 7 years old, whereas 10 of the 15 nongravid elk in the 1954 and 1956 study herds were in younger age classes. It therefore appears that one or more of these circumstances adversely influenced the development of follicles in the 1955 study elk.

If the numbers of follicles in the 12 youngest (average age 3.2 years) nongravid elk from all 3 years are considered, the average number of follicles per cow was 19.8 from 2 mm. to 5 mm., 1.1 follicles from 5 mm. to 8 mm., and 0.5 follicles larger than 8 mm. in diameter. These averages were comparable to those in all gravid elk. Apparently, if confinement interfered with the exhibition of estrus by any young cow, it was not because of lesser follicular development. The lack of breeding in the 1955 group may have resulted from conditions related to old age. Possibly, the old cows could not tolerate as well as the young cows, the unaccustomed conditions of confinement. The presence of corpora lutea in the ovaries of several young cows which did not overtly evince estrus indicated that estrus did occur—probably at night when the cows were not observed.

The size of follicles in elk at maturation and ovulation is not extensively described in the literature. Large pre-ovulatory follicles examined in this study averaged 8.4 mm. and ranged from 8.1 mm. to 11 mm. in diameter. Large follicles in ovaries from pregnant animals ranged from 8.3 mm. to 13 mm., and averaged 9.6 mm. in diameter.

TABLE 4.—AVERAGE FOLLICLE NUMBERS PER PAIR OF OVARIES IN FREE-RANGING AND IN PENNED ELK

Class of Elk	Number of Elk	Average Diameter of Follicles			Total Follicles	Standard Error
		2 to 5 mm.	5 to 8 mm.	8+ mm.		
GRAVID[1]						
Range	10	19.2	0.9	0.4	20.5	±2.31
Penned	5	21.4	2.0	0.6	24.0	±1.62
NONGRAVID PENNED						
1954(5) and 1956(10)	15	19.5	1.1	0.5	21.1	±2.64
1955	7	8.7	0.0	0.4	9.1	±3.53

[1] All range elk were taken before the 80th day of pregnancy; therefore, gravid penned elk which were pregnant for a longer period are not included here.

The 13 mm. follicle was in a cow which had been in gestation for 135 days. Each of two cows in gestation for 90 and 123 days respectively had one follicle greater than 8 mm. in diameter. In this study, all pairs of ovaries which contained follicles greater than 8 mm. in diameter contained only one such follicle per pair, except one pair which had two follicles (each 8.8 mm. in diameter) in the same ovary. Large follicles examined by Halazon and Buechner (1956) ranged from 7 mm. to 9 mm. in diameter in early pro-estrus, from 8 mm. to 11 mm. in late pro-estrus, and from 6 mm. to 10 mm. after conception.

Halazon and Buechner found one recently ovulated follicle which was 17 mm. in diameter. The 13 mm. follicle measured in the present study did not appear to be ready for ovulation. Hammond (1927) found that ripe follicles in various breeds of dairy cattle ranged from 10 mm. to 13 mm., and increased to 15 mm. 24 hours after estrus commenced.

Corpora Lutea

Significance in elk.—A count of corpora lutea does not have the same value for determining the ovulation rate for elk as it does for deer. Elk usually produce only one calf (Murie, 1951; Kittams, 1953), presumably because only one ovum is released during an estrus. The occurrence of multiple corpora lutea in elk is most commonly a result of secondary ovulation (Halazon and Buechner, 1956) after conception has occurred. Therefore, contrary to what occurs in deer, a count of corpora lutea in elk does not enumerate ova released but not fertilized at the time of conception.

Furthermore, a count of corpora albicantia in elk will not accurately enumerate the ovulation or the fertilization rate for the preceding year if corpora lutea from sources other than pregnancy become pigmented and are indistinguishable, by size or other criteria, from corpora albicantia developed from corpora lutea of pregnancy. Golley (1957) found that inaccurate identification of corpora albicantia resulted in an error of 18 percent in determining the ovulation rate of Columbian black-tailed deer. Such evidence necessitates a clearer understanding of ovarian morphology in elk before it can be used with confidence as the basis for a technique used first for white-tailed deer.

Corpora lutea in several stages of development were carefully examined in this study to learn if they could be differentiated reliably by morphological characteristics according to the reproductive success of the cows. Some of the more pertinent data are presented here.

General appearance.—Corpora lutea were generally round when newly formed, and were close to the tunica of the ovary. In older corpora lutea, the shape and position were more variable: some corpora lutea remained near the tunica, others were deep in the stroma. Thirty-four percent of all well-developed corpora lutea were distorted to some degree by the pressure exerted by adjacent growing follicles. The color varied from white to butter yellow (after preservation) in all stages of development, and to orange in the early stages of degeneration.

Early formation of corpora lutea.—Two of the elk studied were sacrificed on December 10, 1956. Neither cow had exhibited heat nor copulated. One possessed a recently ruptured follicle which was 6.3 mm. in diameter. A bloody exudate emanated from the follicular cavity through an open rupture. A layer of luteal cells lined the follicle wall which was greyish-white (after preservation) and wrinkled, and the thecal blood vessels were considerably enlarged. A recently ruptured follicle in the other cow was 6.9 mm. in diameter. The ovulation site contained a large, jagged opening which was occluded with tissue debris. Many large blood vessels formed prominent ridges over the surface of the ovulation site and penetrated the follicle from several places in the theca. The follicle was completely filled with greyish-white, convoluted bundles of loosely arranged luteal cells. These structures were apparently corpora lutea in the very first stages of formation; and, like those in cattle (Hammond, 1927), were ap-

proximately one-half the size of a mature follicle just prior to ovulation.

Corpora lutea of nonpregnant cycles.—Other corpora lutea of ovulation, in elk which were not observed to evince estrus or which copulated only with the vasectomized bull, appeared to develop similarly to corpora lutea in cattle. In early development, there was often a central blood clot surrounded by luteal tissue with an ingrowth of connective tissue strands. After growing for a few days, the corpus luteum increased to 9 mm. to 18 mm. in diameter, and often retained a central cavity which contained a substance similar to congealed (after fixation) liquor folliculi in large Graafian follicles. At complete development, the three largest corpora lutea of nonpregnant cycles were 10.4 mm., 11 mm., and 14 mm. in average diameter. In all of them, fluid in the central cavity was replaced by a plug of connective tissue which branched into many strands. These strands separated convoluted clumps of large, closely compacted luteal cells.

Degenerating corpora lutea of ovulation from nonpregnant cycles were more intensively examined than other corpora lutea because many of them were becoming more darkly pigmented in degeneration, and it seemed important to learn if the pigmentation was similar to pigmentation in corpora albicantia formed from corpora lutea of pregnancy. Nine degenerating corpora lutea from nonpregnant cycles were found; their sizes ranged from 8.2 mm. to 2.8 mm. The larger ones still superficially resembled fully developed corpora lutea; the principal difference was smaller size, commencement of necrosis in the luteal cells, and wrinkling of the theca in the degenerating corpora lutea. The smaller ones consisted mostly of connective tissue, large blood vessels, and scattered clumps of necrotic luteal cells which contained pigment crystals. One of the most regressed corpora lutea was of known age. It came from a cow sacrificed when 30 days pregnant. She had copulated with the vasectomized bull 22 days prior to the estrus in which she was impregnated. The 52-day-old corpus luteum was 2.8 mm. in diameter and was pigmented orange. Considerable whitish connective tissue was scattered throughout it.

Another highly regressed corpus luteum was found in a cow sacrificed when 25 days pregnant. She was not observed to copulate or display estrus until the date she was impregnated; therefore, the date at which she ovulated in the cycle prior to fertilization cannot be stated exactly. Assuming that ovulation occurred 21 days previously, the average estrous interval, the age of this corpus luteum was 46 days. It was 3.8 mm. in diameter, dark yellow, and had been invaded by a small, growing follicle. Another corpus luteum of unknown age appeared to be in a similar stage of degeneration. It was 4.3 mm. in diameter and pigmented light orange; its theca was wrinkled; remaining luteal cells were necrotic and disorganized; and a small follicle was growing into it.

Corpora lutea of pregnancy.—Twenty corpora lutea of pregnancy obtained in this study were histologically identical to the most fully developed corpora lutea of nonpregnant cycles. They differed only in average size. The corpora lutea of pregnancy averaged 14.3 mm. in diameter with a range of 12.9 mm. to 16.5 mm. Corpora lutea of pregnancy in 289 elk examined by Halazon and Buechner (1956) averaged 13 mm. in diameter with a range from 10 mm. to 18 mm. The diameter of the largest corpus luteum of ovulation without ensuing pregnancy (14 mm.) exceeded or equalled all but one of the diameters of the corpora lutea of pregnancy in the elk sacrificed in the nine earliest periods of gestation (up to 60 days), and also at 90 days postfertilization (Fig. 1); but the other mature corpora lutea of nonpregnant cycles were all smaller than the 25-day corpus luteum of pregnancy. The size of corpora lutea of pregnancy appeared to increase until the 70th day of gestation. After that the size varied somewhat (Fig. 1).

Corpora lutea of secondary ovulation during pregnancy.—Of the 289 pairs of ovaries examined by Halazon and Buechner (1956),

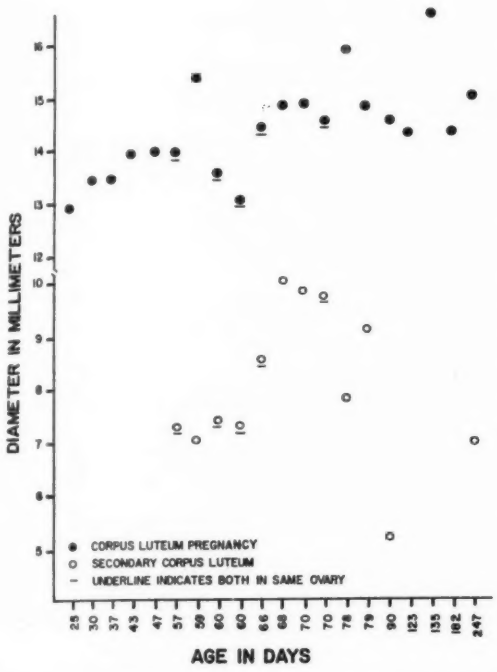

FIG. 1. Diameters of corpora lutea of pregnancy and secondary corpora lutea according to age.

66 percent contained secondary corpora lutea which averaged 7 mm. in diameter and ranged from 5 mm. to 10 mm. Fifty-five percent of the secondary corpora lutea were in the same ovary with the primary corpus luteum of pregnancy. In the present study, 60 percent of the gravid cows had developed secondary corpora lutea which averaged 8 mm. in diameter and ranged from 5.2 mm. to 10 mm. No specimen elk was carrying twin embryos. Fifty percent of the secondary corpora lutea were in the same ovary with the corpus luteum of pregnancy. All secondary corpora lutea were associated with ovulation scars. The secondary corpora lutea were histologically identical to corpora lutea of pregnancy and to fully developed corpora lutea of nonpregnant cycles. In any pair of ovaries from an individual elk, however, it would not be possible to confuse a secondary corpus luteum formed after pregnancy with a corpus luteum of a nonpregnant cycle. The latter would commence degeneration before pregnancy occurred in the next estrous cycle, and would be highly regressed by the time the secondary corpus luteum began to form after conception.

Accessory corpora lutea.—An examination of ovaries from 527 mule deer in Utah disclosed that accessory corpora lutea without ovulation scars were 5 percent as common as corpora lutea of pregnancy (Robinette, *et al.*, 1955). In the present work with elk, luteinized, nonovulated follicles were not intensively investigated because time limitations prevented detailed histological analysis; however, follicles with peripheral layers of what appeared to be luteal cells were found frequently. They rarely exceeded 3 mm. in diameter. Two elk each contained an ovarian structure which appeared to be a completely luteinized follicle. The diameters of these structures were 2.1 mm. and 4.0 mm. Viewed under a dissecting microscope, they appeared to be identical with true corpora lutea except in size and lack of ovulation scars. They are described here because of their possible relationship to the incidence of pigmented scars unrelated to rupture sites, a matter which is discussed in the following section.

Corpora Albicantia

The value of counting corpora albicantia to interpret past productivity in deer is contingent upon the assumption that only corpora lutea of pregnancy regularly become pigmented; and if other luteinized bodies do become pigmented, the corpora albicantia derived from corpora lutea of pregnancy are distinguished by larger size. In elk ovaries, the large number of secondary corpora lutea formed after conception are said to become pigmented (Halazon and Buechner, 1956). In the present study, it was evident that degenerating corpora lutea of ovulation from nonpregnant cycles became pigmented. The accuracy of measuring past productivity of elk by counting corpora albicantia is therefore dependent upon positive differentiation of corpora albicantia according to origin.

The color of corpora albicantia, or pigmented scars, ranged from light orange to dark brown. Most of them were dark orange, reddish orange, or brown. Their appearance, as viewed with a binocular dissecting microscope, varied considerably. Many of these scars contained scattered pigmented areas which were separated by thick, white strands of connective tissue. Other scars were homogeneously pigmented throughout, either lightly or darkly, and the connective tissue was more whorled, convoluted, and compacted. The pigmentation appeared as shiny orange crystals in quadruple-stained histological sections. In some scars, the crystals were found mainly within degenerated luteal cells; in others, particularly the smaller, darker scars, no luteal cells were present in any condition, and the pigment crystals were scattered among the connective tissue cells. The sizes and shapes of scars varied greatly. Few of the scars were round. Most of them were distorted to some degree. Several scars were flattened into a thin layer around a large, growing follicle. Small follicles were pushing into many others.

All pigmented scars in each pair of ovaries were counted and measured, and the largest scar in each pair was determined. The pertinent information derived is presented in Table 5. The two categories, lactating and nonlactating, are based on known breeding histories. As the comparable numbers and sizes of the largest scars in each category were similar, there is no possibility of distinguishing lactating cows from nonlactating cows on the basis of pigmented scar size alone. Other criteria must be developed to identify the corpora albicantia derived from corpora lutea of pregnancy. Such criteria must be sufficiently accurate for macroscopic analysis for the technique to remain simple and practical.

TABLE 5.—OCCURRENCE AND SIZES OF PIGMENTED SCARS PER PAIR OF OVARIES IN LACTATING AND NONLACTATING ELK

Occurrence and Size	Lactating	Nonlactating
Number of elk	26	18
Scars per elk		
Average occurrence	3	3.4
Range	1 to 7	1 to 9
Largest scar in each elk		
Average diameter (mm.)	3.7	3.4
Range of average diameters	1.5 to 6.0	2.2 to 4.3

The incidence of pigmented scars in nonlactating cows is slightly larger than it would have been under natural conditions because some of the scars were derived from corpora lutea of ovulation formed in forced recurrent estrous periods. To exclude these scars from the total count of corpora albicantia, identifying characteristics were sought in scars in the ovaries of two cows known to be virginal prior to copulating with the vasectomized bull. Both cows were 2 years old. One of them had four pigmented scars; the other had two scars. As an additional example, a large orange-pigmented scar in an ovary of a gravid yearling shot in the herd reduction was carefully examined. Since conception in calf elk has not been reported in the literature, this scar was undoubtedly from a corpus luteum of ovulation without conception. It was becoming distorted from a large follicle growing against it.

The pigmented scars in the 2-year-old cows were basically similar. All were orange or reddish orange, and averaged 2.9 mm. in diameter. Viewed under a dissecting microscope, the pigmentation was arranged in scattered clumps between prominent strands of white connective tissue. The pigmented areas were bright and shiny. The ovaries of cows having multiple estrous periods all contained pigmented scars of this appearance; therefore, such scars in all other elk were tentatively considered to be from corpora lutea of ovulation without resulting pregnancy. In cows which failed to show estrus, the average incidence of such scars was one per elk in lactating cows and three per elk in nonlactating cows. The average diameter was 2.9 mm. in the former, 2.8 mm. in the latter.

A second type of pigmented scar was characterized by the lack of a visible ovulation site. These scars were from light orange

to dark brown in color. The ovaries of lactating cows contained an average of 1.5 of these scars per elk; the average diameter was 2.6 mm. The ovaries of nonlactating cows contained 1.2 of these scars per elk; the average diameter was 2.4 mm. Some of these scars may have been derived from luteinized follicles.

Scars in a third category were small and densely pigmented dark orange or dark brown. Connective tissue strands were not prominent, and pigmentation was uniformly dense throughout the corpus. The pigment was not shiny as in new corpora albicantia. These scars occurred in a frequency of 0.8 per cow, both lactating and nonlactating; the average diameter was 1.6 mm. in the former, 1.2 mm. in the latter.

If the pigmented scars derived from corpora lutea of ovulation in nonpregnant cycles and pigmented scars without ovulation sites can be differentiated and rejected from the total, the remaining pigmented scars must represent the corpora lutea of pregnancy. This means that in elk, corpora albicantia of pregnancy are not the largest pigmented scars present as in white-tailed deer. It may be hypothesized that in elk the corpus albicans is largest when newly formed, and it grows smaller, darker, and more compact with age. If we assume that recurrent estrus is infrequent in free-ranging elk, then only corpora albicantia of corpora lutea of pregnancy will be present. Thus, all cows known to have had a calf in the preceding spring should have one of the small, dark, compact scars; and nonparous cows should not have any. Instead of this, an equal distribution was found between lactating and nonlactating cows; and since there was an average of 0.8 scars per elk, it is apparent that some lactating cows did not have any scars of this type.

Some of the cows, both lactating and nonlactating, were found to have so many pigmented scars, which appeared to be newly formed from corpora lutea of nonpregnant cycles, that they would have had to commence ovulating in July, an unlikely possibility. One cow, a 3-year-old known never to have calved, had four pigmented scars, including all three types described above. Of particular interest were the pigmented scars in two dry cows isolated with a yearling bull in 1955. In 1954, Charles Trainer observed one of these cows (A) to have two periods of estrus and the other cow (B) to have one period. Both were bred to the intact bull, but neither cow produced a calf. In the breeding season of 1955, cow "B" was observed to be in estrus twice. The ovaries of both cows were examined in December 1955. The ovaries of each cow contained two pigmented scars which were of the third type described: small, dark, and with compacted tissue. Cow "B" also had 4 large scars which lacked ovulation sites, but did not have any scars which appeared to be recently formed from the 2 estrous periods in 1955. The ovaries from six lactating and two nonlactating free-ranging cows shot in the herd reduction were examined. All cows were gravid. The ovaries in lactating cows contained two pigmented scars per pair which appeared to be from corpora lutea of nonpregnant cycles. They did not contain scars which lacked ovulation sites, and only three of the small, dark scars were found. In one cow that still had her calf at side, the sole pigmented scar present was so flattened around a large follicle it was found only by diligent examination with a dissecting microscope.

DISCUSSION

To be worthwhile, ovarian analysis requires a large sample of ovaries, and a simple method which can be performed rapidly and accurately. Such a method must be based on morphological characteristics which can be readily ascertained macroscopically and reliably associated with each animal's reproductive history.

The evidence obtained in this study indicates that corpora albicantia in elk ovaries cannot be consistently identified and correlated with specific reproductive performance according to macroscopic appearance. All sizes and types of corpora albicantia occurred in cows known not to have calved in

the previous spring as well as in cows which were known to have calved. The probable reason for this is that many scars are retained beyond the second breeding season after formation. In some of the ovaries examined in this study, an abnormally large number of corpora lutea of ovulation from nonpregnant cycles was present, and these corpora lutea were found to become pigmented upon degeneration. However, most of the pigmented scars were derived from corpora lutea of pregnancy or from secondary corpora lutea formed in the prior breeding season. The presence of pigmented scars in nonlactating cows was attributed mostly to corpora lutea of pregnancy formed two or more seasons ago. It was impossible to determine reliably which scars were derived from secondary corpora lutea. Distortion from the pressure of growing follicles affected the shape of many corpora albicantia. The effect of this distortion undoubtedly varies considerably, and it prevents corpora albicantia from having a uniform appearance according to age and origin. A pigmented scar may remain unaffected and appear to be newly formed for several months; or it may be compressed, twisted, or torn apart in a very short time. The scars lacking ovulation sites are difficult to explain. Some could be from luteinized follicles; they may have been disassociated from the rupture site; the rupture site may simply be too small or too well healed to locate. The presence of all types of corpora albicantia in cows known not to have calved in the previous spring indicates that a count of corpora albicantia does not reliably measure past productivity.

Corpora lutea are more reliable indicators of successful reproduction, but there are certain limitations in using them. As indicators of the fertilization rate, the presence of corpora lutea of ovulation in cows not impregnated may introduce an error. If collected too early in the breeding season, the ovulation rate will not be accurately measured because some of the cows may not be physiologically ready to ovulate until some time later in the season. These errors may be minimized by making ovary collections in the latter part of October and early November, well after the peak of ovulation which occurs in early October. This will insure that most cows had a chance to ovulate, and many corpora lutea of ovulation from nonpregnant cycles will be identified because of degenerative changes in their tissues. Since large sample sizes enhance the value of this technique, it is necessary that hunter-killed elk be available during this period. Where the hunting season is still open in late October and early November, embryonic tissues will be visible in some uteri. The greatest value of corpora lutea counts may be a determination of the year-to-year trend in the ovulation rate. If a 100 percent enumeration of reproductive success is desired, a count of embryos is necessary.

Measuring the development and occurrence of Graafian follicles appears to be a possible method of expanding the total knowledge of annual reproduction available from ovarian analysis. It can be used for ovaries collected in September prior to the peak of ovulation, making them useful as supplements to ovaries collected later in the season. A measurement of follicular development may indicate years in which environmental conditions adverse to fecundity occur. This would serve to explain the reason for a lesser incidence of corpora lutea if fecundity is the variable involved.

SUMMARY

Ovaries from elk of known breeding history were examined microscopically and macroscopically. Graafian follicles were found to form peaks of abundance in three size groups: 2 to 5 mm., 5 to 8 mm., and larger than 8 mm. Numbers of follicles were not significantly different in any size group between all gravid and nongravid elk, or between young elk in the study groups and free-ranging elk on the National Bison Range. There was a significant difference between old cows in one study group and all other cows. As gestation proceeded, there was a decrease in average follicle size.

Corpora lutea of ovulation in various stages of development and regression were

found. Large corpora lutea of ovulation in nonpregnant cycles and corpora lutea of pregnancy were indistinguishable from each other except by size after gestation had proceeded for at least 25 days. The corpus luteum of pregnancy grows until the 70th day of pregnancy; then its size changes very little until parturition. Secondary corpora lutea were found in 60 percent of the gravid elk, and were histologically identical to corpora lutea of pregnancy and fully developed corpora lutea of nonpregnant cycles.

Three general types of pigmented scars were identified according to macroscopic appearance, size, and association with an ovulation site. They were found to occur in both lactating and nonlactating cows, and could not be correlated with the specific breeding histories of the elk in a way to measure past productivity.

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A SYSTEM FOR CLASSIFYING PLANT FOODS OF BIRDS

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The plant foods of game and non-game birds need more study, evaluation, and classification to understand their relative use and importance.

This paper has three purposes: (1) to describe terminology useful in classifying quality of plant foods; (2) to discuss methods by which food studies may be improved and interpreted to meet agricultural needs; (3) to show the current need for further studies. It is limited to a consideration of plant foods.

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NEED FOR CLASSIFYING BIRD FOODS

W. L. McAtee (1920:255) summarized the earlier food studies of the Department of Agriculture in his article "Farm Help from the Birds," in a Department of Agriculture Yearbook. He wrote, "From the percentages and economic value of the food items, the utility of a bird can be closely estimated. The Biological Survey is then able to recommend how it [the bird] should be treated. Exhaustive accounts of the economic relations of more than 200 species of American birds have been published by the Survey, and some description given of the status of no fewer than 500 species." These were the excellent studies and many publications of Beal, Cottam, Judd, Kalmbach, Mabbot, McAtee, Merriam, and numerous colleagues outside the Department. The chief objectives then were: (1) to determine the economic status of each species of bird, and (2) to obtain popular recognition, understanding, and protection of birds for their several values. These objectives were well attained by the combined writings of America's scientists and authors; however Kalmbach (1934) expressed a great need for further observation and experimentation related to economic ornithology.

Van Dersal (1938) recognized an agricultural need to understand the wildlife values of the native woody plants of the United States. Graham (1941) followed this objective with *Legumes for Erosion Control and Wildlife*. Kelsey and Dayton (1942) noted the specific plants which were known to have some wildlife usage, by placing the symbol "WL" in their listing of standardized plant names. These three books are useful, but they generally lack two important details: (1) a full list of the birds which feed upon each plant, and (2) differentiation between important and unimportant usage.

Martin, Zim, and Nelson (1951) took a further step in this needed direction, providing a very useful evaluation of the importance of plants to species of birds and mammals. It is our experience, however, that their system is too technical for ready use, especially by agricultural workers, farmers, and laymen. A simpler, yet specific, classification of the plant foods of each bird is needed. We have found that the classification described in this paper serves this need.

DEFINITIONS AND CRITERIA

This classification of bird foods utilizes three separations: choice; fair; and unimportant. For each bird species the plant foods eaten by it are evaluated and placed in one of these three categories. The criteria for evaluation concern the preference shown by the bird and the nutritional value of the food items.

The objective of the evaluation is to provide a basic list of plants suitable for management to favor any specific kind of bird. This classification omits management factors such as yield, rate of deterioration, cultural methods, and costs. Any attempt to combine management considerations with determinations of quality leads to confusion.

Choice Foods

This group includes foods that readily attract a bird when no food shortage or other emergency exists, and are also readily digestible and nutritionally beneficial.

Birds are attracted to these plant foods because of taste, texture, size, color, physiological need, or other undisclosed factors. Birds definitely make such selections among available foods even though the reasons for their choice may be unknown.

Fortunately, foods eaten readily, when free choice is available, give evidence of nutritional sufficiency as indicated by alertness, maintenance of weight, and high reproductive capacity. Obviously a nutritious food must be easily digestible, but this

point has been ignored in many food-habits studies.

For the present, we may accept the hypothesis that no single food is nutritionally sufficient to meet the needs of any bird. Most of the evidence supports this assumption. In a practical sense, however, few birds are limited to a single food item. A variety of green leaves, buds, insects, earthworms, larvae, or other foods are usually available. Thus placement of a food in the choice category does not imply nutritional adequacy by itself—only that it contributes substantially to the bird's energy, growth, and reproduction.

Fair Foods

This second group includes foods that are less attractive than choice foods, but are acceptable during times of stress and are nutritious enough to sustain life. Such foods may be eaten sparingly, or not at all, until primary foods are exhausted or become unavailable due to snow, ice, high water, or some other reason. We may say, then, that foods in this secondary group are definitely deficient in some respect. Both groupings include foods which are acceptable, the first readily without compulsion and the second under some form of necessity. Moreover, the foods in both groups are *important* in terms of their use and ability to maintain life. The term "fair" designates that group which is second-rate, of poorer quality, and of less value or merit than choice foods.

Birds usually exhibit preferences among both choice and fair foods. Orders of "preference" can be developed within each group. Obviously no distinct line can be drawn between the least attractive choice foods and the most readily acceptable fair ones. Fortunately, however, only a few foods fall near this controversial line for any single bird species.

Unimportant Foods

Unimportant foods are those which contribute little or nothing to a bird's diet, but are known to have been eaten by the species. Such food bits usually have been referred to as "trace" items; but foods of choice and fair quality also occur in trace amounts when availability is extremely low.

An indigestible item is unimportant. One taken rarely or only in small quantities is unimportant if it is (1) abundantly available and (2) still not used significantly in times of food stress. Those foods taken accidentally are unimportant.

Making a decision that a plant food is "minor," "unimportant," or "insignificant" has disturbed food-habit investigators. Each decision is simplified, however, by approaching the problem from the bird's point of view, and by making use of several kinds of evidence.

In practice we must ignore the oft-written theory that some minor plant may provide a necessary but minute chemical needed for the bird's welfare. Certainly we may do so until actual evidence from careful research proves otherwise, for trace elements also occur in the choice foods.

We have found that it is better to omit unimportant food items from summary publications. This was done by Martin, *et al.* (1951) and Davison (1958) who simply listed only those foods they considered to be important. By simply omitting the unimportant foods from summary publications, condemnation is avoided of a plant which, with more thorough study, might be found to deserve a higher classification.

This discussion of minor foods is not intended to discourage careful identification and recording of every item found in food-habits research. Such foods should be given a numerical, volumetric, or adjective rating to indicate their relative importance in local studies.

METHODS OF STUDY

Our classification of plant foods for birds is based on information obtained from (1) studying available literature on each bird species, (2) discussing data with field observers, and (3) conducting field trials and studies. The need of a common understanding of criteria to be used in classifying foods accounts for the publication of our procedure at this time.

Usually more than one method of study must be employed to determine the quantities and qualities of foods eaten by any one species, a fact explained carefully by Kalmbach (1934). What we learn by stomach analysis must be verified by field observations or experimental feeding to determine whether the bird takes each food as a free choice where others are available, or that limited availability of choice food causes it to be eaten as subsistence (fair) diet. To prove or disprove availability of other choice foods, it is frequently necessary to provide one or more foods of known quality near the one in question. This process can also be used to rate a bird's order of preference among choice or fair foods at different seasons of the year.

Thus we rely on all the four following methods of study, each of which alone has faults that are recognized by most students of food-habits research.

(1) *Stomach analysis.*—This method has been employed extensively and is exemplified by Martin, *et al.* (1951). In stomach analysis methods, however, hard seeds remain as evidence longer than those quickly digested. Fruit pulp is almost impossible to identify, or evaluate quantitatively, and requires observation and evaluation at the site of feeding. Nevertheless, small seeds taken from the ground, water, or high in trees usually require stomach study to verify observations.

Birds which hold food for a time in a crop or gullet before it enters the gizzard offer unusual opportunities to evaluate their foods by crop-and-gizzard analyses, as pointed out by Davison (1940). A crop shows the quantity of each food which is actually eaten; the gizzard gives some indication of the rate of digestibility. A comparison of the crop and gizzard contents of a bird thus helps place each item in one of the three categories of choice, fair, or unimportant. A series of 100 well-filled crops, collected during a single season in one locality, appeared to be an ample guide to volumes and frequency of seeds taken by bobwhites (Davison, 1942). On the other hand, no number of gizzards without crops will answer the three significant questions of digestibility, the volume eaten, and the frequency taken.

Most birds do not hold food in a crop or gullet. They have no gizzard, simply a stomach. Here, too, the undigestible stones of fruits, hulls of seeds, and chitinous parts of insects indicate use; but the volume of the digestible parts eaten should be calculated also by supplementary evidence. A number of birds such as cedar waxwings, bluebirds, crows, robins, and woodpeckers swallow fruits and then regurgitate the stones and undigested fruit skins. Observation of these feeding birds, combined with identification of regurgitated materials beneath their perches, adds significant evidence to stomach analyses.

We doubt that volumetric criteria can be standardized to separate choice and fair foods. In times of stress, fair foods often account for high percentages. Only a few seeds, however, in a small bird's stomach provide scant evidence for volumetric percentages. Therefore, both volume and occurrence percentages provide only preliminary evidence which requires further verification. One significant improvement in stomach analysis can be made by on-site study at the time of collection. Personal knowledge of the other foods available at the time and place of collection usually is necessary to understand the true significance of each food in question (Kalmbach 1934). In the past, many published studies of stomach contents did not have this important information, as collections were made by laymen and the analyses were made later in a laboratory far away. For the best evaluations, we examine stomach contents immediately, at the site where taken.

(2) *Observation of feeding activity.*—This is a useful and dependable method of food study where a species of bird takes fruits, nuts, and the like from easily seen trees, shrubs, vines, or flowerheads. Numerous choice foods have been unrecorded in stomach analyses but have been shown to be important through observations—flower nectar, watermelon, uncommon fruits, and one to a dozen common foods

of many individual species of birds. Observation of feeding can also evaluate the eagerness and frequency of feeding, the quantities taken, competition between species of birds, and the seasons of use and non-use. As noted elsewhere, it may be necessary to collect a few stomachs to verify what the observer thinks he is seeing, especially in the cases of waterfowl or birds which are feeding on insects and small seeds. It may be necessary sometimes to collect the bird for its positive identification. Valid data by observation have three essentials: positive identification of the bird, the plant, and the parts of the plant being eaten.

The most obvious evidence to indicate unimportance is observation of abundant plant food which a bird refuses to eat. Conversely, a plant food eaten eagerly indicates importance, either choice or fair.

(3) *Feeding experiments.*—Free selection of foods may be determined by offering several kinds of food at the same time to birds in captivity or outdoors. While results from captive birds alone may not apply exactly to the same birds in the wild, Michael and Beckwith (1955) obtained valuable evidence from captive bobwhites. Stoddard (1931), Nestler, *et al.* (1945), Hamerstrom, *et al.* (1941), and others fed separate foods to penned game birds, and obtained useful nutritional evidence by determining relative losses of weight during the period of such experiments.

Nutritional research with domestic poultry suggests the value of various foods to wild birds such as turkeys, pheasants, and ducks. Thus, pending specific research with each species of bird, some general qualities of certain plant foods must be accepted. However, feeding tests for each bird species will be necessary before final nutritional conclusions may be made (King and McClure, 1944), a truth also mentioned by Martin, *et al.* (1951:11–13). Chemical analyses of plant foods are indicators of nutritional value but are not necessarily conclusive in this respect (Wainio and Forbes, 1941).

The digestibility of fruit stones and hard seeds is poorly understood. Without specific research, conclusive evaluation of these questionable plant foods is uncertain.

(4) *Field trial procedures of the Soil Conservation Service.*—These procedures further evaluate the quality of plant foods for individual wildlife species such as bobwhite, mourning dove, pheasant, turkey, geese, and various kinds of ducks and nongame birds. Plant species to be evaluated are established at sites where the birds may be observed. Use is determined by regularity of feeding, and is verified when necessary by stomach analyses.

By these four methods combined, we feel that we have gotten closer to the truths about food qualities. These more comprehensive data give us a better understanding, and replace the current generalization that "availability is the main factor in the choice of foods."

We mimeograph or publish summary classifications of what we now think is reasonably correct, hoping that new research or field studies will be stimulated to reevaluate the foods of individual species of birds and, conversely, the species of birds which find each plant a choice of fair food. A soil conservationist, forester, agronomist, or range specialist most likely will study the problem according to the usefulness of the plants which he deems most significant in his activities. A game manager, ornithologist, or amateur bird watcher may arrange his studies around his favorite birds. We study the problem from both angles.

Assembling the Evidence

First, a card file is established for each bird species to be considered. A digest of the food observations and records, published or unpublished, is made on a separate card for each author or observer. Such notes include the written or verbal source, with full citation for future reference. The compilations of plant foods by individual bird species presented by Martin, Zim, and Nelson formed the basis for much of our classification. In most instances, any food item they distinguished by two or more asterisks (5 or more percent of the diet in any region) was labeled tentatively as a "choice" food.

The items, distinguished by one asterisk or a plus, usually were labeled "fair." As mentioned earlier, Martin, *et al.* (1951:32) omitted many plant items which occurred only as a "trace" in their data, stating: "Most of these numerous minor food items have little known significance in the animal's diet, and presenting their total array would becloud and complicate a picture which attempts to set forth the typical, more important foods eaten."

The classification placed on each individual card is only tentative. As has been stated elsewhere, we cannot reach a decision from volumetric percentages only; we must consider all the reports of stomach analyses and observations. Thus, all the facts known about the foods of each species of bird are gathered together before summary decisions can be made.

Second, a letter-size file is established for each bird. A similar file is also set up for each plant which is reported to be a choice or fair food of any bird in the United States and Canada. Unimportant items are not recorded in these files. We arrange these files alphabetically by common names, using the A.O.U. Checklist (1957) for the birds, and Kelsey and Dayton (1942) and other sources for plants. Each common name is followed by its technical name in both files. Alphabetic arrangement has advantages for the layman, whereas systematic arrangement brings related plants or birds together for the botanist and ornithologist. We in the Soil Conservation Service work primarily with laymen.

Third, a technical-name card file is established alphabetically for all the birds and plant foods. On each card is designated the common name which is used in the letter-size files. Such cross referencing provides a complete index to the common and technical names of our birds and their important plant foods.

Tentative evaluations are made from the evidence which accumulates from all sources available. Where the information is meager or questionable, additional evidence will be sought. Our tentative classification of the foods of each species is available to anyone who is interested enough to consider, correct, and offer additional evidence.

Conflicting conclusions sometimes occur regarding the classification of food items. Some of these conflicts can be reconciled with better knowledge of local availability of the food item and its season of use. Others are clarified when the methods of study are compared, as between the analyses of crops and gizzards. Occasionally the problem of classification is hindered by evidence which indicates a definite preference for individual plants of a plant species, such as pyracantha, Russian olive, cultivated cherries, and grapes.

We are currently concerned with exaggerated importance probably assigned by volumetric and occurrence measurements to hard-seeded items which digest slowly or not at all. Ducks, particularly, swallow lead shot, and many nearly indigestible seeds such as sawgrass, dogwood, blackgum, hawthorn, rose, and similar hard-seeded plants may be misclassified by stomach studies. A general condemnation of these plants, however, cannot be made since each appears to be a choice food to several species. These hard-seeded items must be evaluated carefully by every means possible.

MANAGEMENT FACTORS

Finally, it must be emphasized that this classification is not influenced by economic, geographical, or land management factors such as yield, rate of deterioration, soil and climatic adaptation, and competitive use by other wildlife. These are factors which influence decisions regarding practical management, but they do not alter a bird's preferences. Thus man's selection of plants to protect, destroy, plant, or improve by selection is a separate step.

Producing food is an important part of managing soil, water, and plants for birds. Often the objective is to provide food at one location for only one kind of bird—an upland game species, a particular kind of waterfowl, or non-game bird. Whether we plan to grow food plants agriculturally or provide them by manipulation of the natural environment, our efforts will usually be

better rewarded if we favor the choice food plants.

There might be exceptions, however, in northern climates where it could be important to grow fair foods also, in order to have them available when snow covers the choice food plants or where competition for foods is critical. Several choice foods, for example, cannot be grown satisfactorily for game birds because flocks of unwanted nongame birds such as blackbirds, cowbirds, crows, grackles, and house sparrows destroy the crop before the bird to be favored gets the benefit intended. Grain sorghums, pearl millet, and wild rice are outstanding examples of such foods.

SUMMARY

Four methods of study are discussed for comprehensive classification of plant foods. These are (1) stomach analysis, (2) observation of natural feeding, (3) comparative feeding experiments, and (4) field trials.

A system of classifying the plant foods of each bird species into three groups according to quality is described. It defines the terms "choice," "fair," and "unimportant" which are used to designate these groups, and discusses the criteria by which decisions are made.

Procedures in assembling evidence sufficient to support definite conclusions regarding the quality of plant foods of each bird species are explained.

The problems involved in plant management are not considered in determining the basic qualities of plant foods. Rather, quality is determined from the bird's choice of foods and the plant's nutritional value to the bird.

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THE WILDLIFE SOCIETY

Report of the Executive Secretary for the Year 1959–60

Membership

Again this year the Society has shown substantial growth. The combined member-subscriber total for 1959 was 3,533, an increase of 208 over the previous year. An aggressive, hard-working Membership Committee, under the chairmanship of Lee Yeager, is largely responsible for these additions of new members. Over the past seven years the subscriber-member increase has been 1,205—over 50 percent.

During 1959, 426 new (regular) members were enrolled. This figure is well above that of the year before when 388 were added. These substantial additions of new members, both in 1958 and 1959, are offset in part by losses of old members. However, the net gain for regular members this year was 142 and for life members 33. The number of subscribers to The Journal increased from 507 last year to 538 in 1959.

The present rate of recruitment is running well ahead that of last year. New members for 1960 total 241 compared with 228 over a corresponding period in the previous year.

The death of the following members is reported with regret: Oliver L. Austin, Sr., A. W. Blackerby, William A. Dayton, L. M. Dickerson, T. G. Heaton, Arthur W. Henn, S. Paul Jones, Walter B. Kiener, Floyd L. Parks, William T. Rawlings, and Laurence H. Rubke.

A summary of membership status over the period 1952–59 follows:

The membership was on the move last year, as was indicated by the 1,037 address changes processed during the year. Regular members accounted for 902 of the changes and subscribers for 135. Other mail, including requests for information, election returns, dues payments, etc., raised the incoming total to well over 8,000 pieces.

Publications and Editorial Affairs

After three years of dedicated service to the Society as Editor of The Journal of Wildlife Management, Joseph J. Hickey resigned following completion of the July 1959 issue. He was succeeded by Charles M. Kirkpatrick who began duties with the October issue. During his editorship, Joe Hickey effected new economies in the handling of The Journal and instituted a number of progressive practices. The Society is indebted to him for the excellent job done. During the year, Hickey and Kirkpatrick were assisted in their editorial duties by an Associate Editor (Frank F. Hooper), a Review Editor (H. K. Buechner) and a 15-man Editorial Board.

This year established a record in the number of manuscripts (150) offered to The Journal. However, in spite of this heavy submittal, there is continuing need for longer papers printing seven pages or more. Roughly one-third of the candidate manuscripts were considered unsuitable for The Journal and were rejected, withdrawn or referred to other periodicals. Members of the Editorial Board supplied 160 critiques and recommendations, and referees 69. The current backlog of papers for subsequent issues is 52. Most of these are of short length and longer articles will be welcomed by the Editor.

Even though additional Wildlife Monographs were not published during this fiscal year, excellent progress is being made on this new publication. Three manuscripts have assured financing and are moving along through final stages of editing. All are due to appear this year—the first of these in a matter of weeks. Editor Louis Krumholz also reports that three additional manuscripts have been accepted for inclusion in the series. Funds for two of these appear to be forthcoming, but the third still needs sponsorship.

As Editor of Wildlife Society News, Thomas R. Evans continued his efficient handling of this publication. He acknowledges the fine cooperation of the membership in submitting worthwhile items. This year a considerably larger volume of material was received than could be accommodated in four issues of The News. Proposals for changes in the organization of the Society prompted a heavy response to the editor who regretted that only a portion of the total could be used. As a service to employing agencies as well as Society members,

Table 1.—Wildlife Society Membership, 1952–59

Class of Membership	Enrollments at the End of the Calendar Year							
	1952	1953	1954	1955	1956	1957	1958	1959
Honorary	11	13	15	17	18	18	18	20
Life	10	10	17	27	31	66	80	113
Regular	1,919	2,140	2,346	2,503	2,485	2,619	2,720	2,862
Subscribers	388	377	406	429	441	501	507	538
Totals	2,328	2,540	2,784	2,976	2,975	3,204	3,325	3,533

Mr. Evans has been encouraging state civil service commissions to adjust examination dates to permit job applicants a 30-day period for filing following announcement in THE NEWS.

Final copy was prepared of the *Manual of Game Investigational Techniques* following on comments and suggestions of about 100 reviewers. Arrangements have been completed with Edwards Brothers of Ann Arbor, Michigan for lithoprinting. The publication will have a format of 8½ × 11 inches and will contain about 350 pages. It is expected that the *Manual* will be available in a matter of weeks and no later than the end of March. Information on costs, and where and how to order this long-awaited book, will be announced shortly.

Of further interest to technical workers is a *Wildlife Writing Handbook* currently being brought to printing stage by the author, Werner O. Nagel. Conceived and organized by the National Wildlife Federation, the completed manuscript has been

TABLE 2.—STATEMENT OF RECEIPTS AND DISBURSEMENTS, 1959–60

RECEIPTS			
Bank balance February 22, 1959			$41,024.99
Receipts (deposited to checking account)			
Dues	$19,164.55		
Subscriptions	3,641.81		
Sales			
Back issues, single issues, JOURNAL	1,637.00		
Special publications	809.00		
Amer. Cons. Assoc.—grant for writing handbook	900.00		
Reimbursement on MONOGRAPH No. 3	1,908.99		
Other	54.13	$28,115.48	
Receipts (deposited to savings account)			
Dividends and interest	1,450.06		
Life membership dues	2,947.00		
Redeemed 2 series G bonds	1,000.00		
Sale of contributed books	64.00	$ 5,461.06	$33,576.54
			$74,601.53
DISBURSEMENTS			
Publications			
JOURNAL, printing	$11,357.11		
NEWS, printing	607.75		
Other publications:			
Techniques Manual	173.85		
Maintenance of stencils, postage and mailing of publications	1,886.69	$14,025.40	
Expenses of Editors			
Editorial Assistance	1,067.00		
Honoraria (3 editors)	600.00		
Postage and supplies (JOURNAL editor)	287.58		
Postage (MONOGRAPHS editor)	100.00	$ 2,054.58	
Executive Secretary			
Clerical assistance	1,400.00		
Honorarium	700.00		
Travel and meeting expense	123.65	$ 2,223.65	
General supplies (printing and communications, ballots, dues notices, etc.)	1,357.42		
Meeting expense (awards, delegates, employment desk)	167.31		
Miscellaneous			
Affiliation dues (I.U.C.N.R., N.R.C., Int. Comm. Bird Pres., and Nat. Watershed Congress for 1959 and 1960)	325.00		
Position schedule bond (3 years)	156.25		
Fire insurance on publications (3 years)	174.15		
Refunds, bad checks, bank charges	97.88		
Audit fees	35.00	$ 2,313.01	$20,616.64
Bank Balance February 27, 1960[1]			$53,984.89

[1] Books closed February 27, 1960 to permit auditing before annual meeting.

TABLE 3.—STATEMENT OF ASSETS AND LIABILITIES, FEBRUARY 27, 1960

ASSETS		
Cash		
Checking account (County Trust Co., Md.)	$15,025.39	
Savings Account No. 10282 (Bank of Silver Spring)	10,478.06	
Savings Account No. 15147 (Bank of Silver Spring)	1,067.97	
Permanent fund (Emigrant Industrial Savings Bk.)	9,253.14	
Permanent fund (Perpetual Bldg. Assn., S. S., Md.)	9,221.97	
Permanent fund (Loyola Federal of Baltimore)	8,938.36	$53,984.89
Securities		
44 shares State Street Investment Corp.	$ 1,622.50	
93 shares Loomis-Sayles Mutual Fund, Inc.	1,336.41	
U.S. Treasury Note, Series A (No. 17393) 4¾%	1,000.00	$ 3,958.91
Total assets		$57,943.80
LIABILITIES		
Liabilities		None
Net worth[1]		$57,943.80
Total liabilities and net worth		$57,943.80

[1] Excludes back issues and other publications of indefinite value.

turned over to the Wildlife Society and American Fisheries Society for joint publication and distribution. A $900.00 grant from the American Conservation Association will underwrite publication costs, and distribution to the membership of the Wildlife and Fisheries Societies will involve a nominal cost to cover handling and mailing. Announcements on availability of the handbook will be made this spring.

Election of Officers 1960–61

The Nominating Committee, under W. C. Glazener, nominated E. L. Cheatum and Henry S. Mosby for President, and Jack H. Berryman and Hayden Olds for Vice-president. Candidates for Regional Representative were nominated by the membership following procedures set forth in the Bylaws. Election results were audited by a committee with Gordon Fredine as chairman. The first named were successful candidates.

Nominees for Regional Representative were as follows, the first named being the winning candidate: Region 1, Roger Latham and William R. DeGarmo; Region 2, Leslie L. Glasgow and James S. Lindzey; Region 3, Bill T. Crawford and Ralph A. MacMullan; Region 4, Lee E. Yeager and Ralph R. Hill; Region 5, Wendell G. Swank and W. C. Glazener; Region 6, Howard R. Leach and Jessop B. Low; Region 7, David A. Munro and C. David Fowle. Ballots for nomination and election were counted and audited as required by the Bylaws.

Affiliations and Representation at Meetings

The Society continued its affiliation with the International Union for Conservation of Nature and Natural Resources, the Natural Resources Council of America, the International Science Foundation, the American Association for the Advancement of Science, and the International Committee for Bird Preservation. Society representation in various functions and organizations was as follows: Fred Dale —National Research Council; James McBroom—National Watershed Congress; John Aldrich—A.A.A.S.; Antoon de Vos—International Wildlife Biologists' Congress, The Hague, Netherlands; Jack Culbreath—Conservation Education Association; John M. Anderson—Waterfowl Advisory Committee of the Fish and Wildlife Service; and John L. Buckley, Chairman of Technical Sessions for 25th North American Wildlife Conference.

Society Sections

All Sections continued active during the year, and meetings and conferences, as well as activities of members, have been reported in WILDLIFE SOCIETY NEWS.

Financial Report

Two series G government bonds having a maturity value of $500 each were redeemed at full value and the proceeds deposited in Savings Account No. 10282, Bank of Silver Spring, Maryland. In order to obtain a more favorable interest rate on government securities, an option was exercised to convert two additional series G bonds ($500 each) paying 2½ percent to a series A treasury note (No. 17393) of $1,000 denomination paying 4¾ percent. Loomis-Sayles Mutual Fund, Inc., announced a 200 percent stock dividend payable March 10 to shareholders of record on February 18, 1960. This will increase our holdings in this investment company from 31 to 93 shares.

Society books were closed on February 27 and audited on the same date. A detailed accounting of Receipts and Disbursements for the year, together with a statement of total Assets and Liabilities, is given in Tables 2 and 3.—Respectfully submitted, J. P. LINDUSKA, Executive Secretary.

MINUTES OF THE WILDLIFE SOCIETY COUNCIL MEETING, MARCH 6, 1960

The Council met March 6, 1960, in The Statler-Hilton Hotel, Dallas, Texas. The meeting was called to order by President Charles A. Dambach at 9:30 a.m. Other members present included A. Starker Leopold, Past-President, and regional representatives as follows: Wendell Swank, Leslie Glasgow, Lee Yeager, Jessop Low, Jack Berryman and Dave Munro. Others present as observers or advisers were: Bill Crawford, E. L. Cheatum, Gustav Swanson, Howard Leach, Joe Hickey, Tom Evans and the Executive Secretary.

As the first item of business, President Dambach called upon the Executive Secretary for a report of Society affairs. A detailed report being available to the group, discussion was limited to general remarks on financial affairs and the status of membership.

Editors of Society publications were then invited to report on their work. In the absence of JOURNAL Editor, Charles Kirkpatrick, the President read from Kirkpatrick's report to the Council and took particular note of the current backlog of papers for the JOURNAL. The feeling was expressed that suitable manuscripts on management subjects should be considered for THE JOURNAL. It was agreed that solicitation of these should be made through the pages of THE NEWS.

Louis Krumholz, Editor of WILDLIFE MONOGRAPHS, then remarked on the status of manuscripts for this series. Although no monographs were published last year, Krumholz stated that three papers are scheduled for distribution this year, the first in a matter of weeks. The Editor expressed disappointment that a fisheries paper was not among those due to appear this year. He acknowledged, however, that two excellent manuscripts dealing with fisheries subjects had been accepted. One of these has assured financing, the other is awaiting sponsorship.

Tom Evans outlined events for the year with reference to WILDLIFE SOCIETY NEWS, and told of his work with state civil service commissions in the interest of making THE NEWS a more effective employment medium. The Council agreed to increasing the annual budget for THE NEWS to permit publication of two or more six-page issues. The editors were commended for the fine work on their respective publications.

In the absence of Henry Mosby, the Executive Secretary reported on the status of the *Techniques Manual*. Publication of the manual is being handled by Edwards Bros., Ann Arbor, Michigan, and distribution will be through the office of Henry S. Mosby, Virginia Polytechnic Institute, Blacksburg, Virginia. Considerable discussion followed on the handling of bulk orders and costs to book stores. A motion by Leopold, seconded by Yeager, was passed by the Council recommending that there be a flat charge of $4.50 per volume and that availability of the publication with instructions to purchasers be announced in THE NEWS. It was recommended that the Techniques Committee be continued to keep the *Manual* current.

A report was heard from the Executive Secretary on the status of the *Wildlife Writing Handbook* nearing completion under the authorship of Werner Nagel. The Executive Secretary was authorized to work with the Fisheries Society on distribution of the book and to establish a charge adequate to defray handling and mailing costs. Some Council members, anticipating that demand for this publication may exceed the supply, urged that the plates be preserved in the event that an additional printing may be desired. This interest is to be conveyed to Charles Callison, who is handling publication details with a Washington, D.C. firm.

The Council then reviewed needs for a leaflet on wildlife as a profession and on a motion from Berryman seconded by Low, the Council authorized the incoming President to appoint a committee to prepare an appropriate brochure or to refer the subject to an existing committee.

There was brief discussion on the status of the Employment Committee report and there was agreement that the report when completed should be submitted to the Council prior to publication.

At this point in the meeting, President Dambach introduced Mr. John Olive of the American Institute of Biological Sciences who told of the purposes and function of his organization. Affiliation of the Society with A.I.B.S. was discussed but action was deferred pending the outcome of society reorganization.

On a motion by Leopold, seconded by Yeager, the Council approved continued affiliation with and support of organizations as cited in the annual report of the Executive Secretary. There was discussion of additional affiliation or support of worthwhile activities as follows: (a) the partial defrayment of expenses of a delegate to the Int. Un. for Cons. Nat. and a delegate from the Int. Game Biol. Congress, (b) support of libraries in Africa, and (c) contributions to the Clarence Rhode memorial. The Council acknowledged the worthy nature of each of these proposals, but felt it was not within the financial limits of the Society to support them. In the case of the Rhode fund, it was the consensus that memorials to such individuals should follow the established pattern of recognition through memorial issues of WILDLIFE MONOGRAPHS.

On a motion from Leopold, seconded by Yeager, the Society's annual budget was approved with the addition of $50.00 to the expenses of the Editor of WILDLIFE MONOGRAPHS.

On invitation from the President, the Council offered nominations for honorary membership. Glasgow entered the name of Clarence W. Watson, and Leopold seconded the motion. The Council approved unanimously.

On a motion from Swank, seconded by Leopold,

the Council voted to reappoint C. R. Gutermuth to a 3-year term as trustee.

Resolutions were then heard and Glasgow was appointed to prepare a statement of appreciation to the Wildlife Management Institute and The Statler-Hilton Hotel management for courtesies extended at this annual meeting.

A recommendation of the Employment Committee that it be discontinued and made a part of Professional Training Committee was then discussed. It was agreed that the incoming President should make this assignment and instruct the Professional Training Committee to compile information on student distribution at 3-year intervals.

Through unanimous action of the Council, Editors of THE JOURNAL, THE NEWS and WILDLIFE MONOGRAPHS were retained in office.

The Executive Secretary then expressed his desire to relinquish the office and requested that his resignation be accepted at a time convenient to the Council and under conditions to insure continuity of the office. A motion by Berryman, seconded by Leopold, requested the Executive Secretary to continue until a mail poll of the membership indicated their wishes in Society reorganization. Promptly following on the vote for Bylaws revision, consideration is to be given to effecting the requested change of office.

The President then reviewed in detail proposals for society reorganization and changes of policy and program, and attempted to appraise for the group what he believed the wishes of the membership to be. A lengthy discussion followed in the course of which related reports were heard from committees for bylaws revision and a code of ethics. Both committees were commended for their good work and on a motion from Berryman, seconded by Munro, the Bylaws Committee was requested to submit the code for Council approval and publication in THE NEWS prior to further action and acceptance.

Leopold moved, seconded by Yeager, that recommendations of the Bylaws Revision Committee should go to the membership for a mail vote. The Council then passed a motion by Berryman, seconded by Glasgow, calling for a bylaws change, to be voted on by the membership, recommending dues changes as follows: Student member $6.00, regular member $15.00, life member $200.00, subscriber $10.00, sustaining $100.00, and official $50.00.

It was then moved by Munro, seconded by Yeager, that the Council appoint an *ad hoc* committee to study and recommend ways and means for effecting a mutually satisfactory relationship between the Canadian Society of Wildlife and Fisheries Biologists and the Wildlife Society.

On a motion from Yeager, seconded by Low, the Bylaws Committee was instructed to prepare a ballot embodying proposed bylaws revisions for mailing to the membership.

There being no further business, the Council meeting was adjourned at 11 p.m., March 6, 1960. —Respectfully submitted, J. P. LINDUSKA, Executive Secretary.

MINUTES OF THE ANNUAL BUSINESS MEETING, MARCH 7, 1960

The twenty-fourth annual business meeting of The Wildlife Society was held March 7, 1960 in the Junior Ballroom of The Statler-Hilton Hotel, Dallas, Texas. The meeting was well attended with over 200 in the audience, and the banquet enjoyed a record attendance of 140. Presentation of the Society's Publication and Conservation Education awards took place following the banquet. Details of these presentations appear elsewhere in this report. This year the Society was honored to receive from the Boy Scouts of America a beautifully inscribed plaque in recognition of efforts in behalf of the Scout program.

President Charles A. Dambach called the meeting to order promptly at 8:00 p.m. The order of business followed that prescribed by Section 2, Article 8 of the Society's Bylaws. On a motion by Walter Taylor, seconded by W. C. Glazener, the membership approved the minutes of the last annual meeting, which were published in THE JOURNAL OF WILDLIFE MANAGEMENT, 23(3):332.

The Executive Secretary referred briefly to the financial status of the Society and commented on the growth of membership. For details on Society affairs the audience was referred to copies of the annual report available in the meeting room.

The President followed with his report and acknowledged the services performed by officers and committees of the Society. He then called upon the Executive Secretary for a reading of the minutes of the Council meeting of the day previously. President Dambach elaborated on happenings in the Council meeting and presented details of considerations that preceded actions taken. In particular he reviewed recommendations for changes in the Society that had come to his attention during the previous year and referred to means whereby these changes could be implemented.

Council actions requiring endorsement of members present at the annual meeting were then discussed. A motion was made by Gustav Swanson and seconded by E. L. Cheatum to approve the Council's recommendation of honorary membership for C. W. Watson. The President then read a résumé covering the nominee's background and work in conservation, following which the membership voted unanimously to approve the appointment.

President Dambach referred to the Society awards announced earlier in the evening and invited comments from chairmen of committees who had made selections. Joseph Shomon remarked on

TABLE 1.—BUDGET FOR 1960–61[1]

Publications	
JOURNAL, printing	$11,600.00
NEWS, printing	800.00
Maintenance of stencils, postage, mailing of publications, storage, etc.	1,800.00
MONOGRAPHS—Editorial, printing and mailing (reimbursable)	4,000.00
—Purchase for resale	300.00
Wildlife Writing Handbook	900.00
Techniques Manual—Printing 2,000 copies	5,500.00
—Freight and mailing	700.00
Editorial Expenses	
JOURNAL	
Miscellaneous—Supplies, postage, etc.	350.00
Editorial assistance	1,100.00
MONOGRAPHS	
Miscellaneous—Postage, communications	100.00
Honoraria for editors	600.00
Executive Secretary	
Clerical assistance—Regular plus seasonal	1,400.00
Honorarium	700.00
Travel and meeting expense	200.00
General supplies, printing and communication, postage, mailing of ballots, dues notices, etc.	1,500.00
Meeting expenses (delegates, awards, employment desk)	150.00
Miscellaneous charges (audit, refunds, and bad checks)	150.00
Affiliations	225.00
Contingency fund	600.00
TOTAL	$32,625.00
Less reimbursement in full for MONOGRAPHS	4,000.00
Less reimbursement (on deposit) for *Writing Handbook*	900.00
NET OPERATING EXPENSE	$27,775.00

[1] Anticipated receipts (excluding investment income) is $27,500.00 including $23,000.00 ordinary income, and $4,500.00 from 1st year sales of 1,000 copies of *Techniques Manual*.

the work of the Conservation Education Award Committee as did Kenneth Hungerford with reference to the Committee for Terrestrial Award. Mr. Hungerford informed the group of his committee's wish that an Honorable Mention should go to Mr. Frank C. Bellrose for his publication, *Lead Poisoning as a Mortality Factor in Waterfowl Populations.*

Other committee chaimen were then invited to report on their work. Gustav Swanson explained the recommendations of his committee with reference to a revision of bylaws covering nominations of regional representatives and their tenure of office. He detailed, also, the problems currently associated with present regional boundaries and mentioned proposed bylaws changes for bringing solution to the problem. In the absence of the Chairman of the Employment Committee, Dr. Dambach told of this group's recommendation that the committee be discontinued. He then stated the Council's recommendation for combining the Employment and Professional Training Committees. Paul Dalke summarized the work of the Professional Training Committee, and Karl Lagler requested that a summary of findings be given. Dalke referred to the tabular nature of the material and stated that details would appear in the published report. Edward Kalmbach outlined early efforts to compile information on the history of the Society. As present chairman of the committee assigned to prepare such a history, he appealed to the audience to assist him by providing any historical information bearing on the establishment of the Society. In the absence of the chairman, President Dambach read from the report of the committee for the preparation of the *Techniques Manual.* He told of the Council's recommendation that this committee be continued to provide for continuous revision of the subject matter. A summary of the Membership Committee's report was then presented by Lee Yeager. Leonard Foote referred to the annual report as a source of detailed information pertinent to the Memorials Committee. Stewart Brandborg outlined accomplishments of the Code of Ethics Committee and requested members to submit any

ideas they might have. As chairman of the committee to prepare a monograph on the wild turkey, James Lindzey described the status of the manuscript and noted that Oliver Hewitt had agreed to serve as editor in chief. The committee hopes to have a first draft manuscript completed by January 1961. James MacBroom reported on the work of the National Watershed Congress and the President referred to Fred Dale's report covering the National Resource Council. He took note of the fact that the Council now includes a panel on pesticides. John Anderson as representative for the Society to the Waterfowl Advisory Committee told of the plight of waterfowl over the past year.

There being no dissenting voice the reading of reports of the regional representatives was dispensed with in favor of the next agenda item of unfinished business. At this point, the President invited comments on, or inquiries about, actions of the Council which were stated earlier.

The Executive Secretary replied to an inquiry from George Petrides regarding the present membership and the amount of income expected under the new price schedule for members. John Buckley inquired into the reasons for declining membership with A.I.B.S., the size of the budget for this year, and the anticipated expenditures to cover the proposed new services. Joseph Hickey commented on the possible budget of $50,000, and referred the attention of the membership to his estimate of income that would only net about $36,000. Leopold pointed to new sources of income that might accrue with efforts of a full-time Executive Secretary. John Buckley then expressed agreement with an earlier suggestion of Joseph Hickey that before any actual balloting on dues increases, the membership should be polled informally to determine agreement to dues increases. On inquiry from the audience, Henry Clepper, Society of American Foresters, commented on loss of membership following on dues increases and offered the mailing list of his Society to assist the Wildlife Society in any membership drive they may choose to conduct. Winston Mair told of the nominal effects of dues increases on the membership of the Professional Institute of Public Service (Canada), and mentioned that an increase in members in this organization had followed on employment of a full-time executive officer. Walter Taylor spoke in favor of the dues increases, and Adolph Stebler suggested that the ballot should include explanatory information on what the members may expect in way of additional services as a result of the increase in dues.

The members gave unanimous approval to a resolution read by L. L. Glasgow which expressed our appreciation to the Wildlife Management Institute for making it possible to hold our annual meeting in conjunction with the North American Wildlife and Natural Resources Conference, and thanked the Institute for arranging for the excellent facilities of The Statler-Hilton Hotel.

There being no new business, a motion for adjournment was seconded and passed unanimously. President Dambach declared the meeting closed at 10:30 p.m.—Respectively submitted, J. P. LINDUSKA, Executive Secretary.

ANNUAL REPORTS OF WILDLIFE SOCIETY COMMITTEES

The Aldo Leopold Award[1]

The presentation of this award was made for The Wildlife Society by President Charles A. Dambach at the annual banquet of the 25th North American Wildlife Conference, as follows:

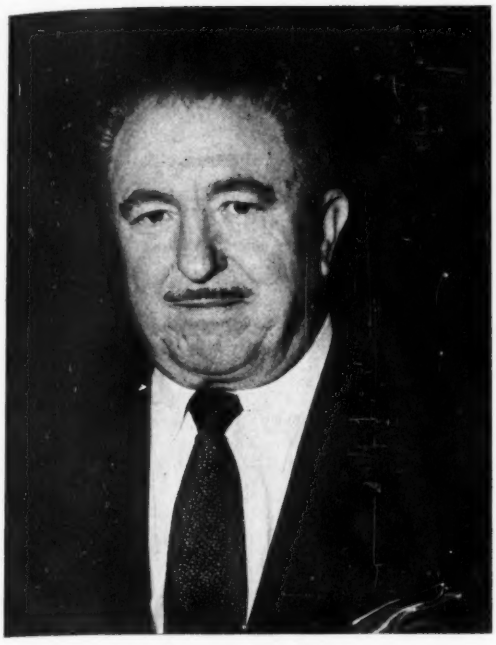
"The Wildlife Society established in 1950 a bronze medal bearing the name and likeness of the late Aldo Leopold whose pioneering work and leadership established the still young but vibrant field of wildlife management. This medal is presented annually, by the Society, in recognition of the highest achievement and service to wildlife conservation.

"Selection of the person to receive the honor rests with a commitee of the Society. Arthur S. Hawkins of the Bureau of Sport Fisheries was chairman of this committee this year. Serving with him were Gustav Swanson of Cornell University; Clarence Cottam, Director of the Welder Wildlife Foundation; A. Starker Leopold of the University of California; and C. H. D. Clarke of the Department of Lands and Forests of Ontario, Canada.

"To the distinguished group of men who have been honored by presentation of the Leopold Medal, there is to be added this year, a man who has distinguished himself in many fields of human endeavor. This year's recipient was born April 26, 1903, in Mexico. He began his career as a revolutionary soldier in that country's war for independence from the Porfirio Diaz dictatorship.

"After the successful termination of the campaign, he abandoned the opportunity to capitalize on the victory and returned to school, graduating from the University of Mexico in 1921. He went on later to take his doctorate in protozoology which he received in 1926. He won a Guggenheim Fellowship in 1932 and worked for a year under Dr. Faust at Columbia University. While serving as a biology teacher at the University of Mexico and as a research protozoologist in the Institute of Public Health and Tropical Disease, he earned a

[1] Previous recipients of the award were J. N. Darling (1950), Carl D. Shoemaker (1951), Olaus J. Murie (1952), Ira N. Gabrielson (1953), Harold Titus (1954), Clarence Cottam (1955), Hoyes Lloyd (1956), C. R. Gutermuth (1957), E. R. Kalmbach (1958), and Ernest F. Swift (1959).



ENRIQUE BELTRAN
Recipient of The Aldo Leopold Award in 1960

world-wide reputation as an authority on filariasis, malaria, and other tropical diseases. Although enjoying a successful career in public health, he felt that the fundamental problem facing his country was conservation of natural resources. He wrote and lectured widely on the subject, finally abandoning his career in protozoology to accept a very tenuous position as organizer and director of the first Mexican Institute of Natural Resources. This institute depended initially upon private contributions and limited government support. It is now a functional and growing organization.

"In addition to directing the Institute and teaching a course in the University of Mexico, he has been appointed by the President of his country as Sub-Secretary of Agriculture in Charge of Forests, National Parks, and Wildlife.

"It is difficult for most of us to realize how much insight and determination was necessary for this man to shape a career in wildlife management in his country. Through the critical years, he has had little support for his conservation ideas. His has been an uphill battle against seemingly overwhelming odds. Through his determined and skillful efforts, it is evident that his country is now well on the road to a sound conservation program.

"It is a distinct pleasure to announce that the 1960 Leopold Medal Award recipient is Enrique Beltran, Sub-Secretary of Forest and Game Resources in the Department of Agriculture of Mexico, Director of the Mexican Institute of Renewable Resources, Professor of Protozoology of the University of Mexico, permanent Secretary of the Mexican Natural History Society, and member of the Executive Board of the International Union for Conservation of Nature and Natural Resources."

Conservation Education Award

The Conservation Education Award Committee considered, all told, 14 separate nominations, covering work in three distinct categories—publications, audio-visuals, and general conservation education programming. After due deliberation and study of the nominations and all supporting evidence, it was decided that the 1959 Conservation Education Award should be made to Richard W. Westwood.

Mr. Westwood was chosen as the recipient of the 1959 award for a number of important reasons. He has long been active in nature education and the work of the Nature Study Society; he was active in the establishment and growth of the International Union for the Protection of Nature (now International Union for Conservation); and, most important, he has rendered distinguished service to conservation education, especially nature appreciation, during his 29-year tenure as editor of the nationally popular *Nature Magazine*, the editorship of which he relinquished upon his retirement in December 1959.

Furthermore, Mr. Westwood's active association and work with natural resources organizations, both public and private, in the promotion of conservation education at the international, national, and regional levels is additional testimony that the award bestowed upon him is both merited and timely.—Respectfully submitted, J. C. CULBREATH, R. K. DAVIS, D. E. WADE, J. B. TREFETHEN, AND J. J. SHOMON, Chairman.

Fisheries Publication Award

W. E. Ricker receives the Fisheries Publication Award for his *Handbook of Computations for Biological Statistics of Fish Populations* (Bull. Fish. Res. Bd. of Canada, No. 119, 300 pp., 1958). (Dr. Ricker was himself a member of this Committee, but asked to be disqualified when his publication appeared on the ballot; the selection was made by the other four members.)

Honorable Mention goes to George A. Rounsefell's *Factors Causing Decline in Sockeye Salmon of Karluk River, Alaska* (Fish. Bull. U.S. Dept. Int., Fish and Wildl. Serv., Vol. 58, pp. 83–169, 1958).

The cited publications were among 16 suggested by members of the Committee or others during the year. Announcements soliciting nominations were sent to each of the Society's Regional Representatives, leaders of the 15 Cooperative Wildlife Research Units, officials of each state conservation department and the U.S. Fish and Wildlife Service, 15 representatives of Canadian fishery agencies, and 60 professional fisheries biologists (mostly at educational institutions). Thirteen foreign periodicals published in English were screened.

At the suggestion of the President, the Committee was polled on two questions relating to eligibility

cf publications. Identical 3–2 votes were cast in favor of restricting eligibility to publications from North America (rather than to papers written in English), and in favor of continuing the present 2-year period of eligibility for both books and papers (rather than extending it to 3 years for books).—Respectfully submitted, W. HARRY EVERHART, JOHN S. GOTTSCHALK, W. E. RICKER, J. H. WALES, AND PAUL H. ESCHMEYER, Chairman.

Terrestrial Wildlife Publication Award

The Committee's unanimous choice for the 1959 wildlife publication award was the work of A. Starker Leopold, *Wildlife of Mexico*, published by the University of California Press, Berkeley, California, 1959. Dr. Leopold's study represents more than 12 years of field study, collecting, and analysis in Mexico, where little work had previously been done.

The Committee awards an honorable mention to the work of Frank C. Belrose, *Lead Poisoning as a Mortality Factor in Waterfowl Populations*, published as Illinois Natural History Survey Bulletin. Volume 27, Article 3, 1959.—Respectfully submitted, JAMES F. BENDELL, E. READE BROWN, ROBERT S. DORNEY, JAMES H. JENKINS, AND KENNETH E. HUNGERFORD, Chairman.

Employment

The Committee's activities were severely hampered by resignation and transfer of personnel. The training and employment report initiated by the 1958–59 Committee is being reviewed for early publication. Liaison activity between prospective employers and employees is being carried out.

This latter function was given considerable scrutiny since the two previous Committees have recommended that it either be handled by the Office of Executive Secretary or through THE WILDLIFE SOCIETY NEWS. A thorough review of the Committee files revealed few instances of cooperation, on the part of persons seeking jobs, in reporting on the success of the Committee's liaison efforts. Further, it is apparent that employing agencies seek the services of the Committee only as a last resort.

In view of the above, this Committee recommends that: (1) The Society take positive action on the recommendation of the 1957–58 and 1958–59 Employment Committees in regard to employer-employee liaison activities; (2) The Society review the 1958–59 Employment Committee's report in regard to continuation of the opinion poll, job turnover and college enrollment inventories, and determine a course of action for the Committee in each case.—Respectfully submitted, WILLIAM B. DAVIS AND GEORGE P. SPINNER, Chairman.

Membership

As in the preceding 2 years, the 1959–60 Membership Campaign of The Wildlife Society consisted of the seven Regional Representatives, plus provincial and state organizations varying from a single Leader to elaborate setups of five or more individuals, each recruiting in separate membership fields. On the whole, this variable approach, with relatively little assistance from the Committee chairman, appears to have worked out fairly well, in view of the somewhat more than 1,200 *new* members added to Society rolls during the 3-year period.

Campaign Highlights

As compiled by the Executive Secretary, new-member enrollment, since 1957, has been as follows: 1957—389; 1958—388; 1959—426. In addition, there has been a reduction in the percentage of delinquencies during the last 2 years.

Due to the constantly changing pattern in membership rolls, attributable to recruitment, delinquency, and changes of address, it is impractical to keep fully up to date concerning campaign progress during the year. For this reason, and also because membership solicitation is by many—Society officers, the Executive Secretary, the Membership Committee, and many interested members—who usually send applications and remittance directly to the Executive Secretary, it is not possible to give here a precise, state-by-state, accounting of campaign success. However, a total of 23 members, some as state leaders, obtained five or more new members during 1958 or 1959 or in both years. The "high scorer" was Walt Sabin of New York, with 23 new members. It should, of course, be remembered that opportunity for recruitment is greatest in populous states with large numbers of professional fish and wildlife employees. It is believed that many, and perhaps most, of the new members obtained since 1957 came as the result of such efforts on the part of 100-odd individuals assisting in the membership campaign.

In both 1958 and 1959, the Committee used to much advantage the brochure, first received late in 1958, describing the objectives of the Society.

Policy

The perennial questions of professional standards and society classes (or the lack of classes) continued to arise during 1959. In many instances this question gave rise to the companion question: How far should the Membership Committee go in soliciting prospective affiliates? In view of the current uncertainty on this issue, and the membership-wide consideration now being given it, the Committee operated without a defined standards policy throughout the year. A definite policy obviously would add to the uniformity of Society presentation on the part of Committee members and others. Officially, of course, membership is open to anyone with an interest in this broad field; the uncertainty and lack of uniformity appears to arise mainly out of the personal convictions of Society representatives as well as potential Society members.

Acknowledgments

To the more than 100 individuals serving in

TABLE 1.—YEARS OF TEACHING AND OTHER EXPERIENCE (PERCENTAGES)

No. Years	Teaching	Conservation Depts.	Federal Service
0	—	23	25
1–2	9	48	62
3–5	18	15	8
6–10	14	10	4
11–20	39	4	1
21–30	20	—	—
	100(92)	100(91)	100(91)

TABLE 2.—PERCENTAGE OF OFFICIAL TIME SPENT IN RESEARCH, GRADUATE INSTRUCTION, ADMINISTRATION, EXTENSION, AND SELF-IMPROVEMENT

Percent of Time	Research	Grad. Instr.	Admin.	Ext.	Self-impr.
0–20	41	46	72	98	63
20–40	35	44	18	1	27
40–60	18	10	8	1	10
60–80	3	—	2	—	—
80–100	3	—	—	—	—
	100(92)	100(92)	100(91)	100(92)	100(91)

virtually every province and state, who shouldered the great load of work incident to the 1959–60 membership campaign, we extend our sincerest appreciation. We are also appreciative of the courtesies and encouragement extended by Society officers, the Executive Secretary, and many interested workers. It was, indeed, the teamwork between field representatives and the Executive Secretary that, to large measure, made possible the success of the 1959–60 membership campaign.—Respectfully submitted, ROGER M. LATHAM, Region I; DON H. STRODE AND LESLIE L. GLASGOW, Region II; JACK BERRYMAN, Region III; WENDELL G. SWANK, Region V; RAYMOND F. DASMANN AND JESSOP B. LOW, Region VI; AND LEE E. YEAGER, Region IV, Chairman.

Professional Training

The Professional Training Committee, this past year, secured information concerning the teachers in the wildlife management field for the academic year 1958–59. The questionnaire is summarized in the tables which follow. The summary is based upon the replies received from 92 instructors in 45 colleges and universities in both the United States and Canada. Not all teachers answered all of the questions. The numbers replying to each category are given in each table. Of the 92 replies, 76 percent of the teachers indicated the Ph.D. as the highest degree earned. The master's degree was the highest earned for 22 percent of the total.

The salary base of 11 or 12 months covered 63 percent of the replies while 33 percent were on a 9 month base and the remaining 4 percent were

TABLE 3.—CREDIT HOURS PER YEAR, LECTURE HOURS PER WEEK, LABORATORY HOURS PER WEEK, TOTAL HOURS PER WEEK (PERCENTAGES)

Hours	Credit Hrs. per Yr.	LECT.	LAB.	TOTAL
		(Hours per Week)		
2–6	4	79	65	66
7–11	26	20	26	46
12–16	32	0	9	34
17–21	20	1		12
22–26	13			1
Over 26	5			1
	100(77)	100(82)	100(79)	100(80)

TABLE 4.—HOURS OF ASSISTANCE PER WEEK

Hours	Percentages
0	48
1–5	26
6–10	15
11–15	10
Over 15	1
	100(81)

TABLE 5.—PUBLICATION RECORD 1954–59, PERCENTAGE PUBLISHING IN EACH CATEGORY

Number of Publications	Books	Bulletins
0	89	73
1	8	19
2	3	6
3	0	2
	100(92)	100(92)
	Scientific Papers	Popular Papers
0	13	45
1–10	67	48
11–20	15	6
21–30	4	0
31–40	0	1
41–50	1	0
	100(92)	100(92)

TABLE 6.—PERCENTAGE OF EACH RANK IN SALARY SCALE

Academic Salary	Inst.	Asst. Prof.	Assoc. Prof.	Prof.	All Ranks
5–6,000	20	5	4	0	4
6–7,000	40	55	17	5	22
7–8,000	40	30	34	5	21
8–10,000		10	41	25	25
10–12,000			0	46	20
12–15,000			4	19	8
	100(5)	100(20)	100(29)	100(37)	100(92)

10 month employees. Only 23 percent had taken any sabbatical leave. The distribution of the 92 teachers according to rank was as follows:

Professor	40 percent
Associate Professor	33 percent
Assistant Professor	22 percent
Instructor	5 percent
	100 (92)

Better than one-half (54 percent) have received no grants or awards for research, while 24 percent have received one or more grants from National Science Foundation, Fulbright, or Guggenheim. Another 22 percent received other unspecified awards.—Respectfully submitted, E. L. CHEATUM, THOMAS L. KIMBALL, VINCENT SCHULTZ, JOSEPH J. HICKEY, AND PAUL D. DALKE, Chairman.

Wildlife Techniques

The Section authors, taking advantage of the comments made by about 100 reviewers, completed the revision of the *Manual of Game Investigational Techniques* during the summer and fall of 1959. Arrangements were made to have Edwards Brothers of Ann Arbor, Michigan compose and lithoprint this publication for the Society. Edwards Brothers will print 2,000 copies, holding the negatives for a later run for the Society should sales justify. This publication will contain about 375 pages, 8½ × 11 inches, 970 words per page, and will be hard-backed. There are 17 text sections plus an appendix, literature cited section and an index. The Council of the Wildlife Society established a "break-even" price of $4.50 per copy, postpaid, to cover cost of printing and mailing.

The *Manual* was indexed by Oliver H. Hewitt and the Committee should like to extend to Hewitt its sincere appreciation for this service to the Society. In addition, Dr. Hewitt assisted in proof-reading the final copy of the *Manual*.

All corrected page proof was returned to Edwards Brothers on February 1, 1960. It is anticipated that the publication should be available about mid-March 1960 or very shortly thereafter.

Orders for this Society publication should be placed with the Executive Secretary [later changed to the office of Henry S. Mosby]. Copies of this publication will be stored and mailed from the offices of the Virginia Cooperative Wildlife Research Unit at Blacksburg, Virginia.

The Committee recommends to Council that it appoint a standing committee on wildlife techniques to review periodically and bring up to date this *Manual of Game Investigational Techniques*.—Respectfully submitted, IAN MCT. COWAN, DAVID E. DAVIS, ANTOON DE VOS, ALEXANDER C. MARTIN, HORACE F. QUICK, RICHARD D. TABER, AND HENRY S. MOSBY, Chairman.

African Wildlife

African Wildlife Conference

Members of the Committee, together with several other persons, explored the possibility of support from the Ford Foundation to establish a program in wildlife research and extension in Africa. It was suggested by the Foundation that an international conference might focus attention on the central issues and determine how a program in conservation of wildlife could contribute to economic, social, and political stability in African countries. Subsequently, Fraser Darling traveled in Africa to ascertain the opinions of government administrators and others on the matter of a conference and reported to the Foundation. It appears that the conference will not win financial backing by the Foundation, but the idea will not be abandoned without seeking other sources of finance.

Conservation Libraries

The Wildlife Society may be able to assist in the establishment and development of strategically located libraries to aid in formulating sound management programs. European and African administrators and field workers frequently have requested reference materials from Fulbright scholars and others with whom they have made contact. It is our view that conservation of African wildlife may be advanced greatly through the creation of small libraries of selected references. These libraries will be of particular significance in countries that achieve their independence within the near future. A good start for this proposed program could be made with $500.00, and the Committee would like an expression from the Council as to whether The Society could provide the funds or whether some other source of funds should be investigated.—Respectfully submitted, WILLIAM M. LONGHURST, GEORGE A. PETRIDES, HELMUT K. BUECHNER, Chairman.

Report of Representative to the National Research Council

This is the third year in which I have represented the Wildlife Society on the Division of Biology and Agriculture of the National Research Council. During this period I have given consideration, with but limited success, to methods by which the Society could profit more directly from its association with the Council. Because of the generally advisory nature of this agency, it often is difficult to translate many of its activities into problems of specific importance to the Wildlife Society. Nevertheless, its contributions toward improving science teaching, the stimulation of interest in biological careers, its influence on the granting of assistance for graduate and postdoctoral research programs, and its influence in setting standards for experimental animals are but a few examples of the importance of this group to wildlife biologists as well as others in biological fields.

One important project, which is of special importance to us and is especially timely now, is the consideration of undesirable side effects of pesticides used in control programs. A committee has been formed, including representatives of agricul-

ture and wildlife interests and of the chemical industry, to consider all aspects of this important problem.

Last year at the annual meeting, I raised the question of how the Society could be brought more closely in touch with the Council. Other representatives expressed a similar need and, possibly partly in response to this expression, the Division of Biology and Agriculture has cooperated to a greater extent in keeping us advised as to Division activities. Suggestions are solicited from members of the Society as to ways in which we can better contribute to the aims of the National Research Council and in turn profit more directly from its activities.—Respectfully submitted, FRED H. DALE, Representative.

Technical Sessions, 25th North American Wildlife Conference

Excellent cooperation of Society members made the Chairman's job most pleasant. In each case, members asked to participate as Technical Session Chairmen or Discussion Leaders accepted, and without exception arranged the technical session programs with a minimum of prodding from your representative.

The problem of adequate quantity, and more especially quality, of papers submitted to session chairmen continues to be acute. The most evident solutions are soliciting a greater number of papers on specific topics from individual contributors, or publicizing the need for papers more widely. Both approaches yielded satisfactory results this year in different sessions.

The difficulty of obtaining papers in the Marine and Coastal Resources Session suggests the possibility of eliminating this session, and replacing it with some entirely different topic.—Respectfully submitted, JOHN L. BUCKLEY, Chairman.

Report of Representative to the National Watershed Congress

The National Watershed Congress received its first impetus about the time when there was widespread support by conservationists and others for authorization of the so-called small watershed program. This was subsequently enacted as Public Law 566 of the 83rd Congress. The program is designed to provide for upstream flood control by means of small dams and other watershed improvements in lieu of the large dams on major rivers built by the Corps of Engineers.

The program is very popular among the farm groups who, under law, must pay for a substantial share of the watershed improvement costs. Most of these groups are soil conservation districts organized under state law. The program is administered by the Soil Conservation Service. So far, 526 small watershed projects in 47 states have been approved for planning and 214 have been approved for installation of works of improvement. The Bureau of Sport Fisheries and Wildlife, in cooperation with the state fish and game departments, has investigated 300 of these projects in reconnaissance fashion and has prepared detailed reports on 7.

The early promise of this program, as being substantially good for fish and wildlife, has been borne out by the fact that over 95 percent of the projects, on which the Bureau has made reports, show benefits to fish and wildlife, or are neutral in their effects. Of the 5 percent of the projects shown to be detrimental to fish and wildlife, most of them involve drainage of wetlands important to wildlife.

In 1958, Congress passed two amendments to the Small Watershed Act. One of these authorized in law the investigation by the Bureau of Sport Fisheries and Wildlife of the small watershed projects; the other authorized the Secretary of Agriculture to pay part of the cost of installing works on these projects for the benefit of fish and wildlife resources. Unfortunately, there has been very little response to this provision. So far, only 4 watershed projects have been approved which involve requests for cost-sharing account of fish and wildlife facilities. We suspect the main problem is one of public access, which is a prerequisite to such federal cost-sharing. Otherwise, local organizations or affected farmers may retain title to their lands utilized by small project works.

The Watershed Congress has been meeting annually for 6 years; about one-half of the meetings have been held in Washington, and the other one-half in various field locations. Last year it was in Dallas, Texas. The purpose of the Congress is to generate interest among a great many groups in the watershed program through discussion with leading national figures in the resources field.

The Congress is managed by a Steering Committee, headed by C. R. (Pink) Gutermuth of the Wildlife Management Institute.—Respectfully submitted, JAMES T. MCBROOM, Representative.

BRIEFER ARTICLES

SHRINKAGE OF MUSKRAT SKULLS IN RELATION TO AGING

Maurice M. Alexander

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Skull characteristics and their measurements have become useful features in mammalian studies. Perhaps they serve best in systematic work, but they also are of considerable help in several other types of study. During the past 10 to 15 years, skull measurements, particularly the zygomatic breadth, have been associated with the aging of such species as the otter (Hooper and Ostenson, 1949), beaver (Friley, 1949; Osborn, 1953; Robertson and Shadle, 1954; Patric and Webb, 1960), and muskrat (Alexander, 1951; Schofield, 1955; Dean, 1957). I became interested in the zygomatic breadth of the skull while attempting to age muskrats that had been caught in February and March, a time when the more commonly used aging techniques are not reliable. The techniques in normal use are based on size and appearance of the internal reproductive organs (Errington, 1939), the size and appearance of the external genitalia (Baumgartner and Bellrose, 1943), the pelt pattern of primeness (Applegate and Predmore, 1947; Shanks, 1948), length of the pelt (Lay, 1945), or dental characteristics (Alexander, 1951; Sather, 1954; Olsen, 1959). The usefulnes of age information in wildlife management has been discussed by Alexander (1958).

Zygomatic Breadth

The zygomatic breadth is measured at the widest point of the zygomatic arches by using a vernier caliper that can be read to the nearest 0.1 mm. This measurement is easy to secure and is one of the least variable that can be taken on the skull or body. It varies primarily with age. However, no technique based on natural phenomena can be expected to give perfect results, and this aging method is no exception. The first problem in its use is the determination of an accurate dividing point that will separate the subadults from the adults. It is known that this dividing point varies among different habitats and sometimes among different years for a single habitat. It is quite possible that population density is also an influencing factor. Sather (1956) has presented data that indicate some variation between the sexes. The limitations in the use of zygomatic breadth as an aging technique must be understood. Further research is in progress. The purpose of this paper is to present a means of standardizing zygomatic breadth measurements to avoid the error that might be caused by the changes that can take place in the tissues of the zygomatic arches.

The skulls used in the initial study were cleaned over a period of several months and measured whenever time permitted. When they were remeasured at a later date, some differences were noted. An approximation of the time and extent of this shrinkage was obtained in 1951, when 59 skulls were cleaned and measured three times while drying. The average zygomatic breadth decreased 0.4 mm. during the first 3 or 4 days, 0.5 mm. in 6 weeks, and 0.65 mm. in 9 months.

Three groups of skulls were collected in the spring of 1957 and cleaned during the following fall and winter. Their zygomatic breadths shrank an average of 0.5 mm. in 2½ weeks, 0.7 mm. in 2 months, and 0.75 mm. in 4 months. This seemed to be their minimum size because when measured one year later, the additional shrinkage averaged only 0.04 mm. It was also noted that the amount of total shrinkage for a particular month was uniform regardless of the habitat or year.

Normal Shrinkage

A detailed study was planned and started in 1958 to determine when shrinkage occurs, its extent, and its uniformity. From this it was hoped to be able to calculate the original zygomatic breadth from measurements taken at varying times. The undamaged heads of 91 muskrats were obtained from the Montezuma National Wildlife Refuge, Seneca Falls, New York, during the first week of February. The heads were measured while fresh, after having been frozen and thawed, and again after having been cooked and while still hot but not cleaned. They were then cleaned and measured while wet, hourly for the first few hours, daily for the first week, weekly for the first month, and each month until a year had passed. The changes in the average zygomatic breadth measurements are shown in Fig. 1. Shrinkage was uniform within this group.

Zygomatic breadth measurements made on fresh heads are believed to be accurate, varying 0.1 mm. or the limit of accuracy in reading the vernier caliper. If the heads become frozen and are then thawed, some hardening or drying of the thin connective tissue over the arches occurs. This makes it more difficult to obtain an accurate measurement, and the variation of change within the group is much greater. However, the measurements on hot, cooked heads and on cleaned skulls can be made very accurately. Therefore heads that have been frozen or partially dried should be measured with caution, and then only after the arches have been scraped free of connective tissue. Cleaning by cooking is more reliable than scraping the arches.

The measurements taken on freshly skinned heads and on heads that have been cooked but are still

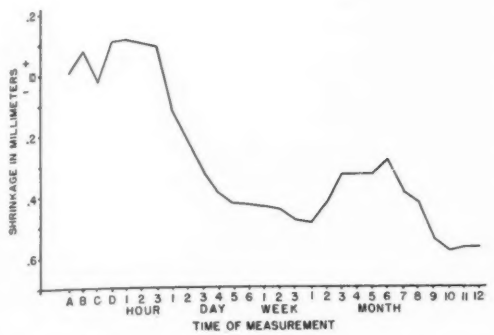

FIG. 1. Average shrinkage of the zygomatic breadth of 91 skulls from March 1958 to March 1959. The figures A, B, C, and D represent measurements on freshly skinned heads, frozen and thawed heads, cooked heads, and wet cleaned skulls, respectively.

hot are essentially the same. There appears to be a uniform increase of up to 0.1 mm. between the hot, cooked heads and the wet skulls after having been cleaned of flesh. Because of this difference it should always be made clear whether one is discussing shrinkage from the freshly skinned head size or the freshly cleaned skull size. The following discussion of shrinkage is based on the freshly cleaned skull.

There appeared to be no shrinkage in the zygomatic breadth during the first hour of drying and only slight shrinkage during the first 3 hours. However, by the end of 24 hours they had shrunk about 0.2 mm., and continued shrinking 0.1 mm. each day for the next 2 or 3 days. Then the rate of shrinkage slowed down rapidly, reaching a total of about 0.5 mm. after 5 days. After 1 month, the total shrinkage reached 0.6 mm. Thus the period of greatest change is the first 5 days of drying. Therefore, for accuracy in actual practice, skulls should not be measured during this period. Measurements on skulls should be taken within a few hours of cleaning or else after a week of drying.

As the periodic measurements progressed, other problems were encountered. The 91 skulls were kept in a laboratory at normal room temperature. The cleaning was done in March and the skulls shrank gradually until May when the heat in the building was turned off. Evidently, humidities also changed and the skulls began to increase in size.

The total increase in zygomatic breadth during the summer was about 0.2 mm. In October the heat was turned on and within a 2-month period the skulls had shrunk to their earlier low point. Shrinkage continued and by the first of the year had leveled off at about 0.7 mm. This gave a difference of 0.3 mm. between summer and winter extremes.

FORCED SHRINKAGE

A series of skulls that had been collected and cleaned in the spring of 1955 were used for experimental treatments. These were from Clay Marsh located north of Syracuse, New York. They had been measured in July 1955 when they should have been near their maximum summer size. They were remeasured in March 1958 and the average decrease in zygomatic breadth during the 3-year period was 0.38 mm. or slightly greater than the summer-winter decrease discussed above.

Some of these skulls were given various treatments including boiling, soaking and drying at 212° F. It was found that they could be increased in size by boiling or soaking, from 0.5 to 0.9 mm., that the larger skulls could be increased slightly more than the smaller ones, and that skulls could be dried in an oven to about 0.5 mm. less than air-dried size.

The remaining 22 skulls were given a uniform treatment of 4 hours of oven drying followed by 4 hours of boiling. The incubation reduced their average size 0.45 mm. beyond air-dried size, and they increased 1.0 mm. from boiling. They then shrank an average of 0.35 mm. the first day, reached 0.5 mm. in 4 days, and their original air-dried size in 2 weeks. During the summer they increased an average of 0.18 mm. followed by a decrease of 0.28 mm. to late winter. These seasonal changes were almost identical to those found in the larger group of skulls from Montezuma. Evidently the extreme treatments had not altered their natural response to seasonal factors.

INFLUENCE OF HUMIDITY

It was quite evident that humidity had played an important part in the fluctuation of skull size between a summer unheated and a winter heated room. Humidity also determined the rapidity and extent of the initial shrinkage of skulls that were cleaned and dried under these two conditions.

Another experiment was run in March and April 1959 with the same 91 skulls used in the above experiment. These were divided into 9 groups of 10 skulls each (1 skull omitted) selected so that each group had the same range of zygomatic breadth. Each of these groups of 10 skulls was then placed in a large desiccation jar that had been brought to a desired humidity level by using a solution of potassium hydroxide in its base (Buxton, 1931). The relative humidities in these jars ranged from 10 to 90 percent at 10 percent intervals. The temperature was that of the room, approximately 24° C. The skulls were kept in these jars for 3 weeks and measured each week. Those at the lower humidities (10 and 20 percent) increased but slightly and this took place in the first week. Those in the medium range of humidities (30 to 60 percent) increased considerably the first week and slightly the second week, and those in the high range of humidities (70 to 90 percent) increased considerably in both the first and second weeks. However, when the skulls were measured at the end of 3 weeks, very few had increased 0.1 mm. and these were scattered without regard to hu-

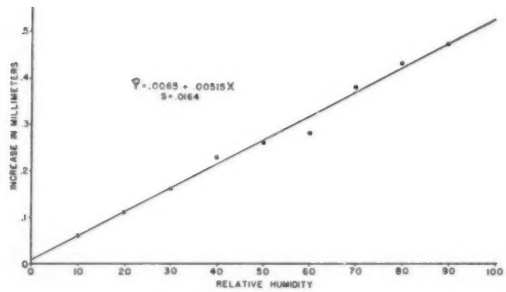

FIG. 2. The regression of zygomatic breadth on relative humidity.

midity level. Fig. 2 gives the increase of zygomatic breadth with the increase in relative humidity. Each point represents the mean of 10 skulls at a given relative humidity. The line is the regression of this relationship, and the standard deviation from it is small (0.0164 mm.). The zygomatic breadth of a skull changes about 0.1 mm. for each 20 percent relative humidity change. If the seasonal difference noted in the summer of 1958 was due to humidity change, a difference of 60 percent would have been necessary to account for the increase in zygomatic breadth. Laboratory humidity was 20 to 25 percent during the winter of 1958–59 and usually 70 to 80 percent during the summer of 1958.

DISCUSSION

The age ratio of a muskrat population, if determined by zygomatic breadth measurements, may be misrepresented unless the effect of shrinkage is known. This is important particularly when the same population is sampled repeatedly for comparative purposes. It is desirable that a standard measurement be selected and the means of converting other measurements to this standard be determined. Assuming that the standard selected is the freshly skinned head size, Fig. 3 gives a theoretical picture of zygomatic breadth change when the skulls are cleaned at various seasons or stored at various humidities. The correction is approximately as follows if the zygomatic breadth is measured a week or more after cleaning or any major humidity change: (1) cleaned June to September, or stored at 80 percent relative humidity, add 0.3 mm.; (2) cleaned May or October, or stored at 60 percent relative humidity, add 0.4 mm.; (3) cleaned April or November, or stored at 40 percent relative humidity, add 0.5 mm.; and (4) cleaned December to March, or stored at 20 percent relative humidity, add 0.6 mm. Although shrinkage averages only about 1½ percent of the average zygomatic breadth, shrinkage can alter the age classification by as much as 10 to 15 percent of the total sample.

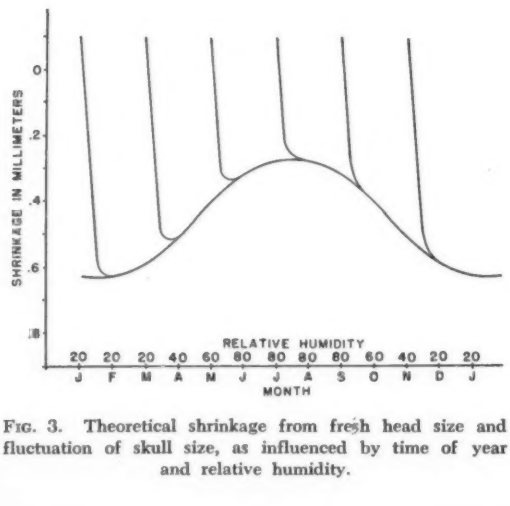

FIG. 3. Theoretical shrinkage from fresh head size and fluctuation of skull size, as influenced by time of year and relative humidity.

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CONSTRUCTION AND OPERATION OF A PORTABLE GOOSE TRAP

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In mid-July of 1956 a reconnaissance of Adams Inlet in Glacier Bay National Monument, 80 miles west of Juneau, Alaska, showed approximately 1,200 flightless adult Canada geese, *Branta canadensis*. A banding operation was launched immediately. Six men caught and banded 168 geese in 7 arduous days. The geese were run down and captured in large dip nets after being driven ashore by boats. The physical hazards involved and general inefficiency of this initial operation dictated a change for future banding.

With the physiography, tidal action and other conditions encountered at Glacier Bay in mind, a trap was designed for use in 1957. Although driving techniques for Canada geese (1956. Guide To Waterfowl Banding. Fish and Wildl. Serv. Sec. 2630) are somewhat similar under most conditions, a trap of greater adaptability than those described seemed desirable. The success of this trap and the 3-year banding operation seems to warrant a publication of the trap design and trapping technique for use by waterfowl banders in other isolated situations such as Arctic and sub-Arctic regions. Appreciation is expressed to Herbert Bonnet, Bureau of Commercial Fisheries, for the illustration and to J. Malcolm Greany, Bureau of Sport Fisheries and Wildlife, for the photos.

TRAP DESIGN AND CONSTRUCTION

For simplicity, strength, and portability, a knock-down quadruped-pyramid type construction was chosen. Four legs of light weight 1½-inch conduit are joined at the apex of the pyramid into one assembly by means of a 3-inch galvanized ring. The ring is split, the conduit drilled and threaded on, and the ring then welded back together. A ring collar is welded onto each leg 3 inches from the lower end. To provide a strong, flexible support for the netting, ⅜-inch manila line is spliced into 2-inch rings and stretched along the baseline of the trap pot to form a square 12 feet 6 inches on each side with a ring slipped over each leg below the collar. Another 2-inch ring is used at the apex of the pot with four ⅜-inch manila lines spliced from this ring to the respective corner rings. When all lines have been spliced into place between the five rings, a 12-foot 6-inch square of netting is tied to the baseline for a trap floor. A clove hitch in series approximately 1½ inches apart secures the net properly. The top ring is lowered from the frame, attached to the center of a 15-square-foot piece of net and then the ring is drawn back up and secured to the ring at the apex of the leg assembly. The edge of the webbing is stretched to the baseline of the trap pot which is laced to the bottom web. On both the front and back side of the trap, 4 feet of the top webbing is not tied to the baseline which allows for placement of the trap door and banding box.

The trap door frame and the banding box door frame are both supported in an upright position and the top web secured to them. The support tubing is secured in place by means of carriage bolts and wing nuts which facilitates setting up and dismantling the trap. The above details are illustrated in Fig. 1. The following material is required to construct a trap 12 feet 6 inches square:

4 pieces galvanized thinwall conduit 1½″ × 10′8″ or equivalent in aluminum tubing.
1 piece conduit 8′6″ long, material as above.
1 piece conduit 3′ long, material as above.
5 steel rings, galvanized, ¼″ × 2″.
4 steel rings, galvanized, ⅜″ × 1½″.
4 carriage bolts, galvanized, ¼″ × 2″.
4 wing nuts, galvanized, ½″.
4 wooden plugs, 1½″ × 3″.
4 pieces manila rope, 5/16″ or ⅜″ dia., each 13½′ long.
4 pieces manila rope, 5/16″ or ⅜″ dia., each 10½′ long.
1 steel ring, galvanized, ⅜″ × 3″.
2 pieces ¾″ O.D. aluminum conduit, each 12′ long.
1 piece aluminum conduit, ¾″ O.D. × 6½′ long.
3 conduit couplers for ¾″ O.D. conduit.
1 panel seine webbing, cotton or nylon, 12½′ square, NTE 1½″ stretched measure between knots. Thread size dependent on size of trap desired (No. 21 recommended for this size trap).
1 panel seine webbing, material as above, 15′ square.
1 net-mending needle.
2 balls linen net-mending twine.
Poultry wire or netting, enough for construction of wings.

TRAPPING TECHNIQUE

Adams Inlet includes the terminal moraine of

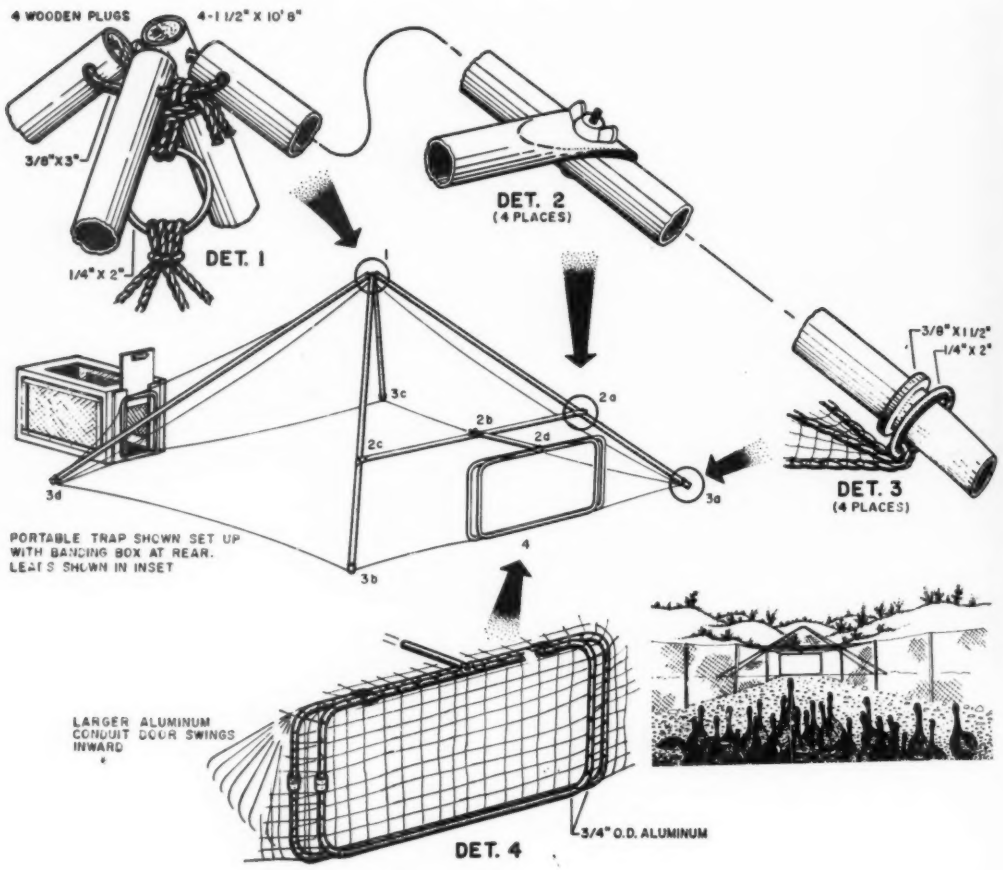

FIG. 1. Details of the Glacier Bay portable goose trap.

Adams and Casement Glaciers. The area is characterized by a rubble of sharp granite boulders and steep gravel mounds interspersed with alder (*Alnus* sp.) and streams laden with glacial silt. The inlet is in a tidal zone with an average fluctuation between high and low water of about 15 feet. These are hazardous conditions at best in which to chase geese and definitely limited the efficiency of the 1956 operation.

The experience gained in handling the geese and observing their behavior under duress on land and water was a key to the success of subsequent trap banding. During early morning many of the geese raft on the open waters of Adams Inlet where they can be herded quite readily with outboard skiffs. There is no nesting in this particular area so that broods are not encountered to complicate the herding procedure.

When pursued on water, geese attempt to escape overland, preferably through cover. The trap is placed to take advantage of this characteristic. There should be background cover adequate to provide the birds with a sense of security as they approach land and start looking for the best avenue of escape. Leads are necessary, diverging from the trap to the edge of the water. A site should be selected with cover fairly close to shore so the leads will be as short as possible. An area should be cleared only large enough to place the trap, banding box and wings. Sparse cover between the leads and in front of the trap will immediately attract the geese when they leave the water. Leafy branches may be leaned against the trap to darken the inside and quiet the birds after they are captured.

With proper boat manipulation, geese can be driven ashore at a predetermined location within the angle of the trap wings. One boat can successfully herd geese to the trap site, but two well-coordinated boats do a better job. When first encountered on the water, geese tend to be wary and flap away from the approaching boats in all directions. The boats should quickly circle the isolated small flocks and scattered individuals to concentrate them into one cohesive group before at-

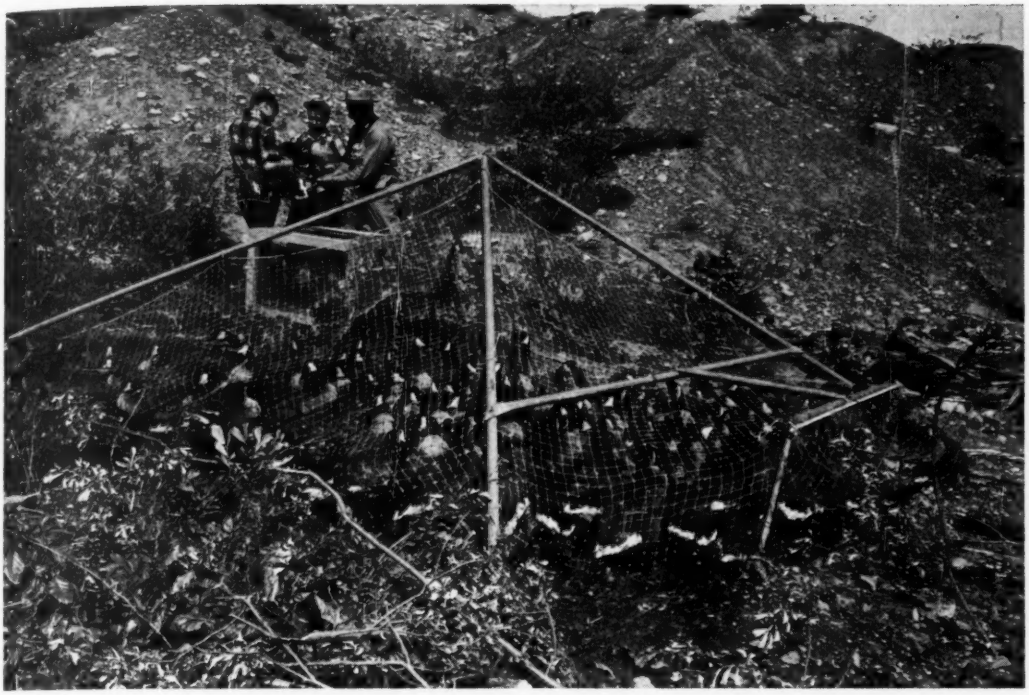

FIG. 2. Camouflage removed to show the results of a successful drive.

tempting to drive them toward the trap site. A slow, cautious drive is less disquieting to the birds than darting movements toward the flock or too much pressure. When driven geese become tired, they attempt an escape by diving. Once a few individuals dive and start sneaking away, others follow and the chance for a successful drive is lost. As the geese approach shore and leave the water they make a break for the nearest cover which, if the drive has been properly executed, is in front of the partially screened trap. It is necessary to land behind the geese quickly and follow them up the beach to force them through the trap door. If a large number of geese (100 plus) have been trapped, it may be desirable to darken the trap to keep the birds quiet during the prolonged confinement.

DISCUSSION

The trap described above has been used successfully during three banding seasons at Glacier Bay, Alaska. The number of resident flightless geese has been relatively stable, between 1,200 and 1,400. The size of the banding crew has varied from four to six men. In 1957, 453 geese were trapped in 3½ days. In 1958, 570 geese were trapped in 3 days and in 1959, 1,142 geese were trapped in 5 days. As many as 260 geese were driven into the trap at one time without loss or injury (Fig. 2). During the three years only 3 geese died out of 2,165 handled through the trap. Birds captured per man hour increased from 0.7 in 1956 to 13.0 in 1959.

The trap is light weight and extremely portable. It can be carried easily by two men. By use of telescoping or sectional legs the trap could be transported by any means, even small aircraft. The trap is rugged and stable, yet holds a large number of birds gently. It can be erected in as little as 15 to 20 minutes plus the time necessary to build wings. Its low silhouette is easily camouflaged and it is easily adjusted to an uneven contour of the ground. The trap is versatile. With a modification in driving techniques, it may be adapted to species other than geese. With a modification of the entrance, the trap could also be used for bait banding. The trap is relatively inexpensive and can be used for several years if the web is properly washed, dried and stored when not in use. If cotton net is used it should be treated with a standard preservative. Either cotton or nylon net should be stored in a dry place away from direct light in order to keep the fibers from deteriorating.

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FALL AND WINTER MOVEMENTS OF BLACK AND MALLARD DUCKS

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This paper summarizes the results of a study of fluctuations in fall and winter populations of black ducks (*Anas rubripes*) and mallard ducks (*A. platyrhynchos*) in central Ohio. The primary objectives were to estimate the duration of stopover of individual birds, and to determine if there was any correlation between local weather conditions and the departure of birds from the study area. Duration of stopover was estimated by trapping and color marking birds; the marked individuals were censused daily until all had departed from the study area. The total population was also censused daily, and weather conditions for those periods when the population decreased in size were examined for any weather factor or factors that might be consistently associated with departures.

This paper is a contribution from the Ohio Cooperative Wildlife Research Unit and the Ohio State University Ornithology Laboratory: U.S. Fish and Wildlife Service, Ohio Division of Wildlife, Wildlife Management Institute, and The Ohio State University cooperating. I am grateful to Eugene H. Dustman and Loren S. Putnam for advice and encouragement throughout the course of the study. Information on the freezeup of the Lake Erie marshes was provided by Robert Donohoe.

The Study Area

This study was conducted at O'Shaughnessy Reservoir, in central Ohio. The physical characteristics of the reservoir are such that a thorough census of waterfowl populations is possible (Winner, 1959).

Methods

Trapping.—The traps used were modified versions of that described by McCall (1954). There is evidence that conditioning waterfowl populations to feed at heavily baited areas may result in a biased sample of the population (Addy, 1953). In the present study, an attempt was made to take the traps to the birds, rather than to condition the birds to come to the traps. The traps were located in areas where the birds normally loafed throughout the day, and were moved periodically so that different segments of the population would be sampled. This method yielded fewer trapped ducks than a heavy, pre-baiting technique, but not a single duck was trapped twice during the same season.

Color marking.—Trapped ducks were sexed, aged (males only), banded with U.S. Fish and Wildlife Service leg bands, and color marked. White, sky-blue, orange-yellow, and red airplane dope were used for color marking. Four or five coats were applied to the plumage, each coat being allowed to dry before the next was applied. Dope was applied to several areas of the plumage, but only markings on the head proved satisfactory. All identifications were made while the ducks were on the water or loafing on the shore. Under these conditions, the head was the most frequently visible portion of the body.

With the exception of red, all colors were easily detected under field conditions. The persistence of airplane dope on the plumage was somewhat variable. During the autumn of 1955, three ducks were marked with airplane dope and held in outdoor cages. The birds had access to a large tank of water and were exposed to all elements of the weather. At the end of 21 days I felt confident that the markings would still have been visible under field conditions. Since 86 percent of all birds had disappeared from the study area within 10 days after having been marked, disappearance of the dope was not thought to be a serious source of error. One duck was observed for 40 days after being marked, but the dope persisted only in patches; under conditions of poor light or at distances of several hundred yards, this bird could easily have been overlooked.

Censusing.—The local populations was censused daily to determine the number of marked ducks still in the area and the total numbers of both blacks and mallards. The census was made during the mid-morning hours after the ducks had settled down from their morning feeding flights and when the sun was at the back of the observer, giving optimum light conditions. The trails paralleling the east short of the reservoir were driven in a car and the ducks were counted through a 25 × spotting scope clamped to the car window. By stopping periodically, areas of observation were overlapped so that no section of the reservoir was missed.

Whenever possible, the number of ducks present was determined by a direct count. The point at which direct counts became impossible was variable, being determined primarily by the compactness of the rafts of ducks. Except when the rafts were extremely compact, it was possible to count populations of 4,000 ducks or less with considerable accuracy. When the ducks were more widely dispersed, populations of 5,000 to 6,000 ducks could be counted successfully.

Annual Buildup of Population

The populations of blacks and mallards were quite low throughout October. The first big in-

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crease in the local population occurred in the latter half of November during each of the three years of the study. Each year there was a large increase in the study area population during the days immediately following the initial freezeup of the Lake Erie marshes. This should possibly be expected since Lake Erie is the nearest source of a large waterfowl population to the north of the study area. In 1954, the Lake Erie marshes froze on December 3; within the next 2 days, the study area population increased from 657 to 1,587. In 1955, the marshes froze on November 17; by November 20, the study area population had increased from 284 to 1,289. In 1956, the marshes froze on November 22; by November 24, the study area population had increased from 777 to 1,796.

Peak populations and dates of occurrence for the 3 years of the study were: 3,987 ducks on December 17, 1954; 8,000 ducks (estimated) on December 12, 1955, and for several days thereafter; and 4,500 ducks (estimated) on December 14, 1956. In 1955, the study area held a waterfowl population throughout January. Observations were not made during January of 1956 and 1957.

DURATION OF STOPOVER OF MARKED DUCKS

The data on the duration of stopover of individually marked ducks must be considered as minimal estimates. The actual duration of stopover must have, in most cases, been longer than the data indicate. There is no way of knowing how long the birds were on the study area prior to being trapped and marked. In addition, the effects of being trapped and handled during marking may have caused some birds to depart more quickly than they would have under undisturbed conditions.

During the 1954 season, 97 ducks were color marked; of these, 83 were black ducks and 14 were mallards. During the 1955 season, 83 ducks were color marked; 35 were blacks and 48 were mallards. During the days following the marking of each group of ducks, the study area was censused to determine the number of marked birds remaining. Table 1 summarizes the data on the duration of stopover of these birds. The duration of stopover, after marking, varied from 0 to 40 days. The mean duration of stopover for these 180 ducks was 4.5 days. The day after marking, 51 percent (91 ducks) had disappeared; 86 percent (154 ducks) had departed from the study area within 10 days or less after being marked; only 6 percent (11 ducks) remained in the area more than 15 days after being marked.

The duration of stopover for mallards ranged from 0 to 18 days, with a mean stopover period of 3.4 days. The duration of stopover for blacks ranged from 0 to 40 days, with a mean stopover period of 5.3 days.

WEATHER AND DECREASES IN THE POPULATION

Various components of weather have long been thought to be related in some way to the migration of birds. In the present study, records were kept of known decreases in the local population of blacks and mallards. These decreases were of two types, decreases in the marked duck populations and decreases in the total unmarked populations. There is certainly a degree of error in censusing waterfowl populations. Recounts of populations during the present study usually did not vary more than 10 percent. To be entirely safe, I have designated only those days on which there was a population decrease of 20 percent or more, as days of known population decreases.

The actual hour of departure of the ducks from the study area is, of course, unknown. The daily census was conducted in mid-morning, and all that can be said is that the departures occurred in the interval between two consecutive censuses. The most probable times for the initiation of migration are early morning or late evening, the times of maximum daily flight activity. The ducks were very seldom observed to fly from the reservoir at other times of the day. In view of this, I summarized the weather data for the intervals between those consecutive censuses which revealed a decrease in either the marked population or the total populations of either blacks or mallards.

Of 63 days on which decreases of 20 percent or more were recorded in the local population, 20 days involved the total unmarked population, 38 involved the marked population, and 5 involved both marked and unmarked populations.

The weather during the periods of population decreases is characterized by its variability. No one weather factor or combination of weather factors was consistently associated with these periods of departure. Ducks left the area under almost every

TABLE 1.—DURATION OF STOPOVER FOR 180 MARKED DUCKS

Number of Ducks	Stopover (in days)
91	0
15	1
8	2
1	3
4	4
5	5
1	6
6	7
12	8
8	9
3	10
4	11
6	12
1	13
3	14
1	15
1	17
3	18
1	30
2	31
1	35
2	37
1	40

TABLE 2.—SUMMARY OF WEATHER DATA FOR THE INTERVALS OF FIVE LARGEST POPULATION DECREASES

Population Decrease for Period		Time	Sky Cover[1]	Barometric Pressure	Temperature (degrees F.)	Relative Humidity	Wind
Mallard	Black						
			DECEMBER 17–18, 1954				
1,238	2,749	1300	10	28.84	38	91	SSE
to	to	1900	10	28.78	44	96	SSE
434	559	0100	10	28.77	37	83	SW
		0700	10	28.76	33	89	SSW
			JANUARY 9–10, 1956				
490	1,017	1300	10	28.90	41	74	WSW
to	to	1900	10	29.06	37	70	WSW
288	645	0100	10	29.12	36	68	WNW
		0700	10	29.15	34	67	NNW
			JANUARY 11–12, 1956				
307	800	1300	0	29.16	38	56	ENE
to	to	1900	10	29.21	34	67	Calm
102	625	0100	10	29.15	33	78	SW
		0700	10	29.11	31	84	SSW
			JANUARY 13–14, 1956				
	438	1300	10	29.05	28	73	WNW
	to	1900	10	29.19	25	80	W
	167	0100	5	29.23	23	80	WSW
		0700	10	29.29	23	80	WSW
			DECEMBER 1–2, 1956				
1,600	1,400	1300	10	29.12	39	63	W
to	to	1900	10	29.12	36	78	SSW
1,000	1,000	0100	10	29.03	33	78	S
		0700	10	28.92	35	73	SSW

[1] Sky cover recorded in tenths of sky covered by clouds.

possible combination of weather conditions. There were departures during periods of falling barometric pressure and during periods of rising barometric pressure. Most departures occurred under conditions of overcast skies, but others occurred during periods of clear or partly cloudy conditions. During periods of departure, winds were most commonly southerly,while humidity was quite variable.

Table 2 summarizes the weather conditions for the 5 days on which the greatest population decreases occurred. None of the departures from the study area approached in magnitude the mass migrations which sometimes occur in areas where large waterfowl populations congregate. However, the weather conditions that prevailed, during the periods of the two largest population decreases, are enlightening (Table 2). During the period December 17–18, 1954, the local population decreased by 2,994 ducks; during the period December 1–2, 1956, the local population decreased by 1,000 ducks. Both decreases occurred during periods when the sky was completely overcast, the barometric pressure was falling, and southerly winds prevailed. The temperature did not change appreciably during these periods.

The literature concerning the relationship of weather to migratory movements of birds is somewhat conflicting. Bellrose (1957), in discussing one of the largest mass migrations of waterfowl that has been recorded, states that the flight began under conditions of low barometric pressure and overcast skies. Hochbaum (1955) in discussing mass migrations witnessed at Delta, Manitoba, says that they are characteristically initiated during periods of rising barometric pressure and clear skies. Both authors were referring to migration of waterfowl in general, but in neither case did the observations involve black ducks. In relation to wind direction, Hochbaum (1955) states that a wind from the northwest is typical of migratory periods, while Bellrose (1957) indicates that the wind was at right angles to the line of flight (westerly) at the beginning of the migratory movement. Hochbaum (1955) associates the initiation of migration with a drop in temperature, while Bellrose (1957) concluded that the cumulative effect of several cold days was more important than a single sharp drop in temperature. Hochbaum (1955) also mentions a drop in relative humidity as being associated with the initiation of migration.

Certain weather factors may tend to stimulate mass waterfowl migrations. However, it appears that migratory movements, perhaps on a lesser scale in regard both to the numbers of ducks involved and to the distances traveled, occur during almost any combination of weather conditions. Apparently, in the case of blacks and mallards, some birds will migrate when the proper physiological condition is reached in spite of what the weather may be. This conclusion may not be valid for

other species or for all parts of the range. In particular, it should be noted that the relative proximity of central Ohio to the wintering grounds of some of these birds may be of significance in the manner in which they respond to weather conditions.

SUMMARY

Fluctuations in autumn and winter populations of black and mallard ducks were studied over a 3-year period. The autumn buildup of populations appeared to be associated with the initial freezeup of the Lake Erie marshes.

The duration of stopover was determined for 180 black and mallard ducks after they were color marked. The mean duration of stopover was 4.5 days. Within 10 days after being marked, 86 percent of the ducks had departed from the study area; only 6 percent remained more than 15 days after being marked.

Weather conditions were analyzed for 63 days on which the local population was estimated to have decreased in size by more than 20 percent. In general, the departures from the study area seemed to be unrelated to weather conditions. However, the two largest decreases occurred during periods when the sky was completely overcast, barometric pressure was falling, temperatures were relatively constant, and winds were southerly.

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A DEVICE FOR ANESTHETIZING SKUNKS

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Our current investigation of sylvan rabies in Illinois (National Institutes of Health Research Grant E-1349) required the handling of skunks for bleeding and tagging. Handling skunks without exposure to their musk or to the possibility of being bitten was facilitated by intraperitoneal injections of liquid drugs from a device allowing an operator to stand about 9 feet from the animals (Fig. 1).

Nembutal sodium (pentobarbital sodium) solution (60 mg. per cc.) at a rate of 1.0 cc. per 6 pounds of body weight (estimated) is a safe anesthetic for skunks. Of more than 50 striped skunks (*Mephitis mephitis*) given this drug, only one died before release, and subsequent autopsy revealed that its death was caused by a cardiac puncture made to withdraw blood. In order to reduce the chances of infection resulting from the intraperitoneal injection, we administer 10,000 units of penicillin and 5.0 mg. dihydrostreptomycin intramuscularly to each animal before it is released.

The following pieces of equipment or material are required for construction of the anesthetizing device. These materials were purchased from local sources for about $3.50.

1- by 5-inch piece of 3/32-inch aluminum sheeting stock.

84-inch automobile hood-release cable.

1-inch by 8-foot piece of Reynolds "Do-It-Yourself" aluminum tube.

¼- by 1⅜-inch light compression spring.

¾- by 8-inch maple or birch dowel.

¾-inch wire brad.

¼-inch flathead sheet-metal screws (two).

FIG. 1. Administering an anesthetic to a skunk in a steel trap.

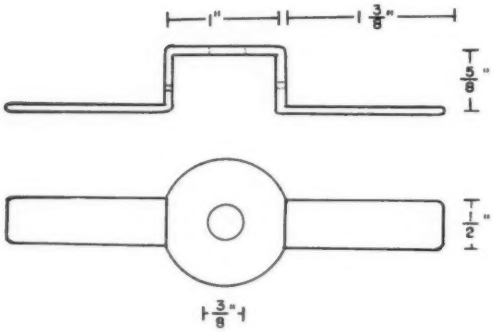

FIG. 2. Tube cover and finger rest fashioned from a piece of 3/32-inch aluminum sheeting stock.

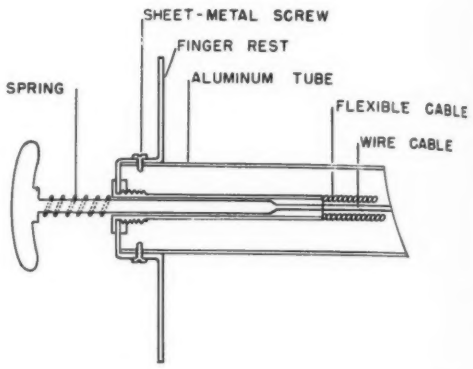

FIG. 4. Upper end of aluminum tube showing how parts are assembled.

The piece of 3/32-inch aluminum stock is cut and shaped to form both a cover for one end of the tube and a finger rest (Fig. 2). The hood-release cable is inserted through the 3/8-inch hole drilled in the cover, and held in place by the nut supplied with the cable. The inside wire cable of the hood-release cable is removed and the spring placed between the handle and the tube cover. When reassembled, a small loop is made at the end of the inside wire cable and fastened by the brad in a slot sawed into the end of the dowel (Fig. 3).

One end of the aluminum tube is cut and shaped as shown in Fig. 3. The slot in the end of the tube is adjusted by lightly bending and/or filing so that a standard 5-cc. Leur-Lok syringe will be held securely when pressed into the opening. The syringe should be easily removable. Care should be taken to bend the lower edge of the tube slightly inward to insure that the piston and barrel of the syringe are held parallel to the long axis of the tube.

The dowel and control cable are inserted in the upper end of the tube and fastened in place with 2 small sheet-metal screws through holes drilled in the finger rest and tube (Fig. 4). The dowel should be cut to the proper length after trial to see that a syringe filled to the 3-cc. level can be inserted and the piston fully depressed. For use with other species, alterations in design may be necessary in order that amounts exceeding 3-cc. may be administered.

Skunks are less likely to expell musk if the operator's approach is slow and deliberate, and if the needle is placed against the abdomen and inserted by pushing steadily. Skunks which make an active defense usually direct their musk at the syringe end of the device.

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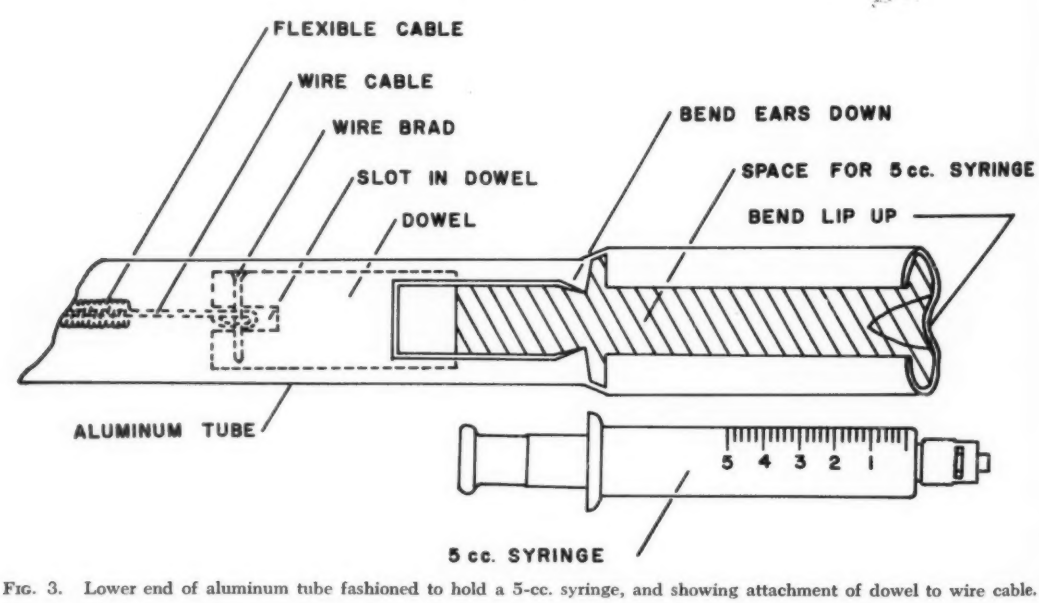

FIG. 3. Lower end of aluminum tube fashioned to hold a 5-cc. syringe, and showing attachment of dowel to wire cable.

DETECTION OF ELK MIGRATION THROUGH HUNTER INTERVIEWS[1]

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Elk (*Cervus canadensis*) migrations are well known but not fully understood. A thorough knowledge of elk migrations would be useful to the wildlife manager. Population analysis and migration data enable the wildlife manager to predict elk losses on the winter range and to direct his management program to eliminate these losses. In 1957 the Idaho Fish and Game Department and the Idaho Cooperative Wildlife Research Unit initiated an intensive study of elk migrations. The purpose of this study was to add to the meager amount of information about the elk of Idaho by an indirect method of collecting data.

Indirect methods have been employed to locate animal population concentrations and detect shifts in these concentrations. Frequency of crow counts have been used to detect movements in pheasant populations (Kimball, 1949). The number of pheasants killed per unit of time has been utilized as an index to pheasant populations (Allen, 1956). In much the same manner, Hayne (1949a, 1949b) used trap-retrap frequencies to define rodent populations and home ranges. Periodic aerial surveys have been used to determine elk migration patterns (Robel, 1960). The number of hours required to sight an elk was first used to detect elk migration in 1957 (Robel, 1958).

The objectives of this study were threefold: (1) to determine elevational distribution of elk from hunter interviews; (2) to determine whether or not there were significant changes in the mean elevation of the elk population during the October 1–31, 1957 hunting season; and (3) to evaluate the hunter interview survey system.

The assistance of Levi L. Mohler and Wesley M. Shaw, Idaho Department of Fish and Game, is greatly appreciated. Paul D. Dalke, Idaho Cooperative Wildlife Research Unit, cooperated in this study. The advice and criticisms made by Allen W. Stokes and Jessop B. Low, who reviewed the early stages of this paper, were most helpful.

Description of Study Area

This investigation was conducted in the lower Selway River drainage of north central Idaho. The study area extended from the town of Lowell, Idaho to Selway Falls, a distance of approximately 15 miles. The Selway River formed the southern boundary while Coolwater Ridge (dividing line between the Selway and Lochsa drainages) and Gedney Creek comprise the north and east limits of the study area respectively.

For the most part, the study area is a steep south-facing slope. The Selway River flows in a westerly direction at an elevation of about 1,500 feet. Coolwater Ridge, extending in an east-west line, averages about 6,500 feet in elevation. This 5,000-foot elevational change takes place in a lateral distance of only 4 miles.

Methods

The survey system was based on the number of elk sighted per hour hunted rather than the number of elk killed per hunter hour. This method eliminated two possible biases—the hunter's marksmanship and selectivity. The hunters were distributed rather evenly over the entire study area. A ratio of the number of elk sighted per hunter hour compensated for any minor deviation from an even hunter distribution. Over the entire hunting season, about 25 percent of the data were collected from sportsmen hunting in the 2,000- to 3,250-foot elevational zone, 35 percent from hunters in the 3,250- to 4,750-foot zone, and 39 percent from sportsmen pursuing elk in the 4,750- to 6,500-foot zone.

Since most hunters were unable to pinpoint their hunting area, it was necessary to interview personally each hunter and piece together the facts. When the hunter was suspected of being unsure of his hunting location, or of giving misleading information, his data were not included in the final tabulation.

An attempt was made to visit the hunter camps at least once every 3 days. These personal contacts were made in the evening after the day of hunting was completed. Approximately 50 percent of all sportsmen hunting elk on the study area were interviewed.

Results

The number of hours hunted and frequencies of the elk sightings were divided into two 10-day periods and one 11-day period (Table 1). Of the 2,858 hunter-hours recorded, more than 50 percent were tabulated during the first 10 days of the hunting season. The frequency of elk sightings varied but little during the entire hunting season. The first 10 days of the hunting season were slightly more productive; 8.8 elk were sighted per 100 hunter hours while the second and third periods each showed 6.3 elk sighted per 100 hunter hours.

As the season progressed, the frequency of elk sightings decreased in the higher elevations and increased in the lower elevations (Table 2). From

[1] Contribution from Pittman-Robertson Research project W 85-R-9, Job No. 3, the Idaho Fish and Game Department and the Idaho Cooperative Wildlife Research Unit cooperating.

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TABLE 1.—ANALYSIS OF DATA COLLECTED IN HUNTER INTERVIEWS DURING THE OCTOBER 1–31, 1957 IDAHO ELK SEASON

Period Number	Dates (Oct.)	Total Hunter Hours	Elk Sighted per 100 Hunter Hours	Mean Elevation (feet)	S.D. (feet)
1	1–10	1516	8.8	4189±96[1]	964
2	11–20	773	6.3	3473±169	1522
3	21–31	569	6.3	3231±100	802

[1] Standard error of the mean.

TABLE 3.—ANALYSIS OF THE MEAN ELEVATIONS OF ELK REPORTED IN HUNTER INTERVIEWS DURING OCTOBER 1–31, 1957 IDAHO SEASON

Between Periods	Degrees of Freedom	"t" Tests
1 and 2	171	3.71[1]
1 and 3	159	4.91[1]
2 and 3	136	1.74[2]

[1] Significantly different at the 95 percent level.
[2] Significantly different at the 90 percent level.

calculated data, population concentrations showed a gradual downward movement during the entire hunting season, from 4,189 feet at the first of the hunting season to 3,231 feet at the latter part of the season (Table 1).

From the "t" test used to determine whether or not the differences among the mean elevations of the elk concentrations during the three periods could be due to chance alone, it was found that the elevational differences were based on movements within the animal population (Table 3).

DISCUSSION AND CONCLUSIONS

No accurate count was made of the actual number of sportsmen that hunted on the study area; however, the investigator estimated that about 500 sportsmen spent some time hunting elk on the study area during the 1957 elk season. More than half of these were personally interviewed.

As respects elevation, the elk population was well dispersed over the entire range throughout the hunting season as shown by the large standard deviations. The relatively small standard errors indicate that the mean elevations of the elk population are relatively valid (Table 1).

One of the largest obstacles to this type of study is the hunter himself. Personal biases and antagonistic attitudes toward fish and game departments in general were the most frequently encountered difficulties. The fact that many hunters were unable to describe adequately their hunting location was a reason for discarding much otherwise useful information received from them. Gordon (1941) and Hunter (1949) encountered similar problems when interviewing hunters to obtain biological and financial information.

In the future our wildlife will have to be managed on a more intensive basis. Even with their many shortcomings, hunter-hour surveys of this sort can be of great value to the game manager.

TABLE 2.—DISTRIBUTION OF ELK SIGHTED PER 100 HUNTER HOURS IN DIFFERENT ALTITUDINAL ZONES

Altitudinal Zone (feet)	ELK SIGHTED PER 100 HUNTER HOURS		
	Oct. 1–10	Oct. 11–20	Oct. 21–31
2000–3250	31	41	47
3250–4750	42	14	11
4750–6500	25	20	5

SUMMARY

During the 1957 Idaho elk season, a hunter-hour survey was conducted in the Selway River drainage of Idaho to detect elk migrations by means of hunter interviews. In the course of the October 1–31 season, 2,858 hunter hours were recorded. Calculations involving hours hunted and elk sighted determined the mean elevation of the elk population. The "t" tests of the data indicate that the differences in mean elevations were due to differences in population concentrations, not to chance alone. The hunter-hour survey was concluded to be an acceptable technique with which to detect and measure elk migrations in Idaho.

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SARCOPTES INFESTATION OF A FISHER

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A scabies infection has been reported for the marten by Cowan (1955), but no record of scabies in the fisher has been found.

A mature male fisher (*Martes pennanti*), shot January 23, 1959, in Cumberland County, Maine, was brought to this laboratory by D. Stanton. It was very thin, with large areas of encrusted skin on the ventral surface of the body and the lateral surface of the legs. The inguinal region was discolored, brown, and foul-smelling. A small piece of the encrusted material was removed, placed in a 10 percent solution of sodium hydroxide for 6 hours, and examined with a low power microscopic objective. Numerous mites (*Sarcoptes scabei*) were observed. Portions of the encrusted skin and preserved mites are stored at the Animal Pathology Laboratory, University of Maine, Orono.

One of the major foods of the fisher in this area consists of porcupines (Coulter, 1959) which are commonly affected with scabies (Payne and O'Meara, 1958). Scabies infections of this magnitude could cause serious fur damage and debilitation in the fisher.

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FALL FOOD OF THE SORA RAIL IN THE ARKANSAS RICE FIELDS

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The sora rail (*Porzana carolina*) is an abundant fall migrant through the Arkansas rice country, reaching peak numbers about September 15 during the middle of the rice harvest season. More than 400 soras were recorded as they were flushed from a single 5-acre rice field September 21, 1954. First migrants arrive on the Arkansas Grand Prairie in early August and most of the population moves southward by early November.

When the first migrant soras appear, most of the rice fields are green. However, seeds of several other aquatic plants found in rice fields are available to them. Jungle rice (*Echinochloa colonum*), cyperus (*Cyperus strigosus*) and aquatic insects furnish an early and plentiful food supply. Other rice field aquatic plants are present, but they mature during late August, about the same time as the domestic rice (*Oryza sativa*).

The feeding activity of redwinged blackbirds (*Agelaius phoeniceus*) and wind action shatter some rice seed, increasing its availability to the soras. At the time of harvesting, additional rice becomes available because 3 to 5 percent of the crop is lost in the field during harvesting.

An analysis of the food of the soras, while they are in this area, was made through an examination of the contents of 56 stomachs collected near Stuttgart in September and October from 1950 through 1954. Domestic rice constituted approximately 75 percent by volume of the soras' food, occuring in 48 of 56 stomachs examined (Table 1). The remainder was made up of rice field weed seeds (19.4 percent) and aquatic insects (6.1 percent).

Table 1.—Stomach Contents of 56 Sora Rails Collected from Mature Rice Fields at Stuttgart Arkansas, September–October, 1951–54

Food Item	Number of Stomachs in which Food Item Occurred	Percent by Volume
PLANT		
Rice, *Oryza sativa*	48	74.6
Echinochloa spp.	16	9.7
Cyperus sp.	15	2.5
Brachiaria extensa	9	2.2
Digitaria sp.	1	1.8
Setaria glauca	1	1.6
Paspalum Boscianum	16	1.3
Panicum capillare	3	0.2
Polygonum sp.	2	trace
ANIMAL		
Odonata nymphs	10	3.2
Curculionidae	2	1.4
Tabanidae larvae	2	0.9
Orthoptera	7	0.2
Laphygma frugiperda	1	0.2
Aquatic Coleoptera larvae (undet.)	7	0.2
Dytiscidae	2	trace
Belostomatidae	2	trace
Arachnida	1	trace

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AN AUTOMATIC CAMERA DEVICE FOR RECORDING WILDLIFE ACTIVITY

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The design and construction of the photo-recorder described here were prompted by the need to make continuous records of small mammal and bird activity where the presence of an observer or traps would involve undesired variables and costly expenditure of time. The recorder had to be completely portable, compact, and capable of operating several consecutive days without attention. O. P. Pearson (1959. A traffic survey of *Microtus-Reithrodontomys* runways. J. Mamm., 40:169–180) has described and illustrated the use of such a device, but it requires a 110-volt A.C. power source and hence is not truly portable. Also we felt prospective users might desire a more detailed description to aid them in constructing such an apparatus. We have seen other plans for automatic tripping of the camera shutter (see, e.g., Gysel, L. W., and E. M. Davis, Jr. 1956. A simple automatic photographic unit for wildlife research. J. Wildl. Mgmt., 20:451–453, and references cited therein), but these do not include an automatic film advance mechanism.

The instrument which we devised is made up of three basic units—an electronic flash gun, a 16-mm. movie camera, and a photo-electric actuating mechanism. The flash unit is a U.S. Camera Corporation #6550 flash gun with the circuit modified as shown in Fig. 1A. This unit is designed to operate with power from either a 110-volt A.C. source or a battery pack. The A.C. source is, of course, unacceptable for a portable apparatus, and the available battery packs are unsatisfactory because of the amount of standby current drain. Since, under field conditions, it is necessary to have the flash unit ready at all times for instant flashing, the standby loss becomes excessive. We therefore modified the flash gun to utilize five 67½-volt batteries in a circuit with very little standby loss under a continuous "ready" condition. With this circuit, approximately 2,000 flashes can be obtained from one set of batteries. The schematic diagram for the modification was obtained from M. C. Maschek, U.S. Camera Corporation, 17 North Loomis Street, Chicago 7, Illinois. There are many battery powered electronic flash units on the market, and probably most would be suitable for use in this way. We used the one described above because it was relatively inexpensive. The flash gun is mounted in the cover (Fig. 2) and the batteries in the chassis (Fig. 3) of the recorder housing.

The spring-wound cinecamera is a Palliard-Bolex 16-mm. equipped with a 1.9f lens and capable of taking single frame exposures. It is mounted on the chassis (Figs. 2, 3) with a knurled bolt to facilitate easy removal. The lens is flush with the recorder housing and provided with a rain hood. The camera was fitted with a flash synchronization mechanism by Norfolk Camera Repair, Norfolk, Virginia. The contacts are installed in the camera with standard flash fittings. Although Pearson (1959) described a simple way of synchronizing the shutter to the flash gun, we felt it would be more satisfactory to have the synchronization built

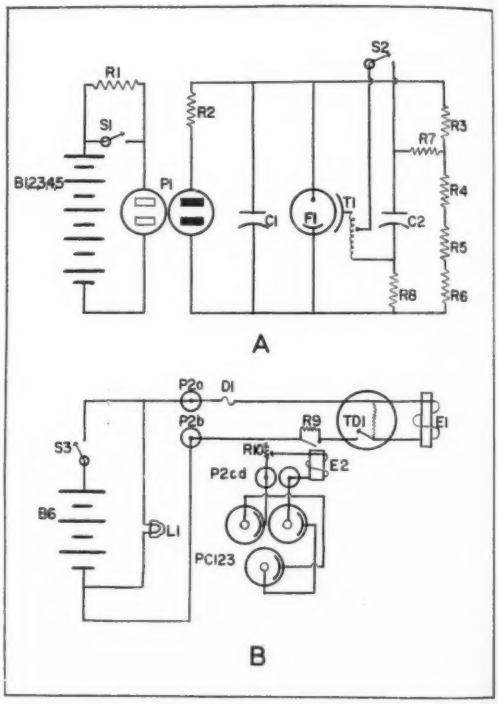

FIG. 1A. Modified circuit of U.S. Camera #6550 flash-gun. B1,2,3,4,5: five 67½-v. "B" batteries in series; C1: condenser, 650-mfd., 300-v.; C2: condenser, 25-mfd., 200-v.; F1: electronic flash tube; P1: plug and socket, std.; R1: resistor, 4,700-ohm, 1-watt; R2: resistor, 1,000-ohm, 2-watt; R3,4,5,6: resistors, 300-K-ohm, ½-watt; R7 and R8: resistors, 2.2-megohm, ½-watt; S1: switch, toggle, SPST; S2: synchronization contact in camera shutter assembly; T1: trigger coil.

FIG. 1B. Shutter tripping circuit. B6: battery, 6-v., 300-amp.-hr.; E1: solenoid, 6-v., 1.35-amp., pull in force, 39 oz.; E2: micropositioner (Barber-Colman Co.) pull-in 76 micro amp., 0.604-v.; D1: fuse, 15-amp. (optional); L1: lamp, 6-v., 0.5-amp.; P2a,b,c,d: phonoplugs and jacks; PC1,2,3: solar cells (Hoffman S1-A); R9: resistor, 1,000-ohm, ½-watt; R10: resistor, var., 0–200-K-ohm; S3: switch, micro, SPST; TD1: relay, time-delay (Amperite, 5-sec., nc.).

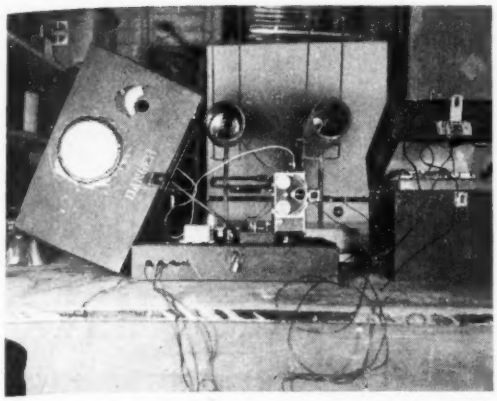

FIG. 2. View of entire unit showing camera housing (with cover detached), battery housing, and "eye" on yokes.

in by a professional concern. Other makes of cameras could be used, the only requirement being a spring-operated film wind which can be set to advance one frame at a time. In the absence of a single frame advance mechanism, the film could be exposed at a motion picture rate, but this would be exceedingly wasteful and would greatly reduce the length of time the recorder could be left unattended. For those on a very limited budget, it might be possible to obtain an old, but usable, movie camera. If a 35-mm. movie camera were used, somewhat better detail could be obtained in the picture, but the cost of film and processing would be increased. Also, 35-mm. movie cameras are harder to find on the used market.

The shutter is tripped by a solenoid which in turn is actuated by the photoelectric circuit. The solenoid is connected by a mechanical linkage to the shutter release of the camera. This linkage is the least standardized part of the whole apparatus. It should be designed, in place, when the other parts are assembled and ready for fastening to chassis. In our apparatus the linkage is a horizontally mounted lever with a fulcrum near the center, with one end attached to the solenoid bar and the other end to the shutter release. It was necessary to adjust the precise locations of these attachments several times before proper functioning was obtained.

The shutter-tripping circuit (Fig. 1B) is basically an "electronic eye" design and operates on the same principle. A 6-volt wet cell battery, housed in a separate unit (Fig. 2), is the power source for the exciter light and the tripping solenoid. The "eye" consists of 3 Hoffman S1-A Solar Cells in series. A narrow beamed light is produced by a 6-volt 0.5 amp. bulb mounted in a metal reflector. A Ray-O-Vac Nite Hawk headlight is suitable for this component. When the light beam reaches the solar cells, their output activates a relay (micropositioner) which keeps the solenoid circuit open. When the beam is broken, the relay releases, closes the solenoid circuit and thus trips the camera and flash. A 2-ohm resistor may be placed in series with the lamp to lengthen its life, but this decreases the intensity somewhat. The circuit is provided with a time-delay relay in parallel with the solenoid which opens the entire circuit if the beam is blocked for 5 seconds or more. Resistor R9 protects the micropositioner contacts. Resistor R10 provides for control of input to the micropositioner.

Both housings are constructed of ¾-inch weather-

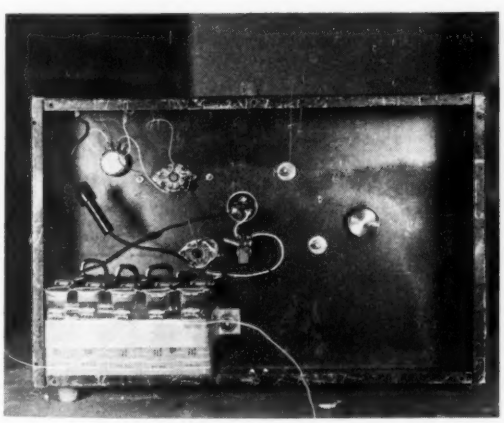

FIG. 3. View of underside of chassis showing "B" batteries and wiring. Knurled bolt for camera attachment at right center.

FIG. 4. Recorder shown as in operation. Note "eye" and exciter light tubes on adjustable yokes.

proof plywood glued at all corners; the exterior is painted flat-black. Both are provided with hinge-hasps and padlocks which in turn can be locked to a chain and anchored to a tree. The joint between cover and chassis is sealed with a rubber gasket to prevent moisture from entering. The 6-volt battery housing is provided with a microswitch arranged to open the solenoid and exciter light circuits when the cover is removed.

The eye is housed in plastic tubes 8 inches long, 4 inches O.D., mounted on yokes with fittings to allow vertical adjustment. The yokes are ¼-inch rods welded to a ⅜-inch steel peg for driving into the ground (Figs. 2, 4). When necessary, the entire yoke assembly is braced by additional supports to form a tripod-like affair.

In operation the beam is directed across the animal pathway and adjusted for proper height and distance between the exciter light and solar cell. In studies to date, the light was covered with red cellophane, and an 8-day clock and dial thermometer were inserted in the camera field so as to appear in each exposure. Fig. 5 shows the kind of photograph one may expect to obtain with the apparatus.

The recorder could be provided with a treadle-microswitch in place of, or as a supplement to, the photoelectric switch. As indicated above, the camera could be set to take a motion picture series rather than a single frame. A modification of the circuits and use of additional time-delay contacts would make it possible to use the setup for making time-lapse photos at various intervals depending on the relay inserted. Other possibilities will likely become evident to users of the instrument.

By purchasing a used camera and synchronizing the shutter as described by Pearson (1959), one could build the complete apparatus including batteries for $150.00 or less. If a treadle switch were substituted for the photoelectric unit, the cost could be reduced another $40 to $50.

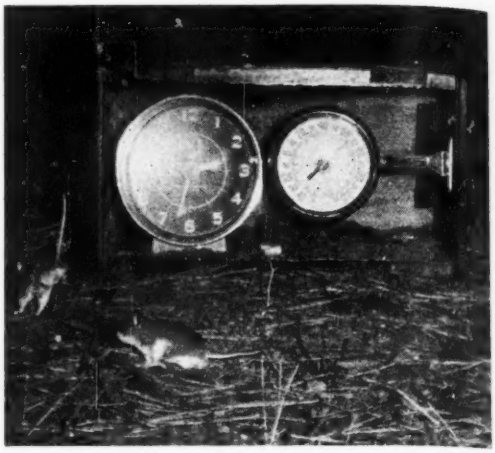

FIG. 5. Enlargement of 16-mm. black and white negative showing typical results which may be obtained. Time shown is a.m.

SUMMARY

An automatic photo-recorder with wide application in the wildlife field is described. It is relatively inexpensive, compact, and readily portable without dependence on A.C. power sources.

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DETERMINING HUNTING SEASON WASTE OF DEER BY FOLLOWING FOX TRAILS[1]

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In December 1955, the Michigan Department of Conservation began an extensive study of the winter food habits of the red fox (*Vulpes fulva*) in the northern half of the Lower Peninsula. This was a companion study to our survey of the relations of the red fox to the ring-necked pheasant (*Phasianus colchicus*) completed in 1955 (Arnold, 1956). The latter study involved the following of fox trails in the snow for a total of 1,000 miles in the southern agricultural areas of Michigan. We designed the present study to gain information on the extent of fox predation on ruffed grouse (*Bonasa umbellus*) in winter.

Tracking during the winter of 1955–56 made it apparent that deer (*Odocoileus virginianus*) shot and wasted by hunters during the fall hunting season were the primary winter food for foxes in northern Michigan. Fox trails led from one deer carcass to another. Therefore, we took advantage of this behavior of foxes, to determine the effectiveness of the trailing technique in locating deer carcasses, and more accurately determining the magnitude of this illegal drain from our deer herd in representative areas of our deer range.

[1] A contribution from Pittman-Robertson Research Project W-69-R, Game Division, Michigan Department of Conservation. I wish to thank all of the personnel of the Department's Game Division who assisted with the study. Student aides, employed as fox trailers, have my sincere thanks. S. C. Whitlock and R. A. MacMullan deserve special mention because of their helpful suggestions. C. T. Black edited the manuscript.

TABLE 1.—HUNTING SEASON WASTE OF DEER, ON THREE SAMPLE AREAS IN MICHIGAN, AS DETERMINED BY TRAILING FOXES[1]

	Miles of Fox Trails Followed	Deer Marked Nov. 15–30	Deer Found by Foxes		Calculated Loss	Calculated Waste/Sq. Mi.
			Marked	Unmarked		
GLADWIN FIELD TRIAL AREA (8 square miles)						
1956	171	13	10	12	29	3.6
1957	155	5	1	11	60	7.5
RIFLE RIVER (7 square miles)						
1956	148	10	7	8	21	3.0
1957	105	13	9	3	17	2.4
WHITE CLOUD FIELD TRIAL AREA (9 square miles)						
1957	62	5	1	5	30	3.3
Totals	641	46	28	39	157	
Average						4.0

[1] All deer were fawns, does, or short-antlered bucks except one unmarked legal-antlered buck found in the White Cloud sample.

TECHNIQUES

We selected two areas for study during the winter of 1956–57: the Gladwin Field Trial Area (8 square miles in Gladwin County) and the Rifle River Area (7 square miles in Ogemaw County); we added another, the White Cloud Field Trial Area in Newaygo County (9 square miles) in the winter of 1957–58. All three study units supported stands of pine (*Pinus Strobus* and *P. resinosa*) before logging in the late 1800's. These areas are now largely covered by aspen (mostly *Populus tremuloides*), oak (*Quercus ellipisoidalis, Q. rubra,* and *Q. alba*), white birch (*Betula papyrifera*), and other vegetation that normally follows logging and fire. Scattered through the areas are small northern hardwood and coniferous swamps. The Rifle River and several small tributaries cross the Rifle River Area. The Cedar River and its tributaries run through the Gladwin Field Trial Area.

The Gladwin and Rifle River areas are state-owned; the White Cloud study area is in the Lower Michigan National Forest. Consequently, all three are heavily hunted during the fall deer season. The Gladwin unit and part of the White Cloud area are field trial areas for grouse dogs, closed to small game hunting. At Rifle River, registration of hunters provides accurate records of hunting pressure and game yields.

Two-man crews, assigned to each study unit during the bucks-only deer season of November 15 to 30, interviewed hunters and located all illegally killed deer reported. They then recorded on a map the location of the deer found, cut the ears off to avoid duplication, and marked each carcass with a numbered tag hung on a tree near the animal. Following the deer season, another set of investigators, not knowing locations of marked deer, followed fox trails on the study areas. They recorded the location of all deer found, both tagged and unmarked, and similarly marked each carcass not bearing a tag. Lincoln-index calculations (Lincoln, 1930) yielded an estimate of the total wasted deer on the study areas. At the completion of each winter's work, we relocated all marked deer not found by fox trailers to make sure they were still there and that hunters had not removed any.

RESULTS

The 641 miles of fox trails followed on the three study areas during the two winters (Table 1) led us to 61 percent of the deer marked during deer season. We found a high (74 percent) proportion of the marked sample during the first winter. Because of poor tracking conditions during the second winter, we located only 48 percent of the marked deer. Almost equal mileages were logged each winter, and the number of marked deer on the areas studied was the same (23). However, the second winter's coverage was not as intensive as that of the first, since we added the White Cloud area and increased the total area of our study units by 9 square miles. In addition to the marked deer, fox trailers located 20 unmarked carcasses the first winter and 19 the second.

Trackers located an individual deer carcass for each 7.5 miles of trails followed. Foxes led us to several of these carcasses two, three, and even four times. In comparison, during the entire fox–ruffed grouse study (1,109 miles of trail), foxes visited a deer carcass on the average of once for each 5.5 miles of trail. We could not possibly tell how many individual dead deer were involved in the latter computation, since revisits to the same carcass did occur and were not differentiated except on our three study areas.

DISCUSSION

The fox-tracking study, although undertaken to determine the predation by foxes on ruffed grouse,

yielded a technique for determining fall and winter losses of deer on small areas. Serious limitations to the method, of course, are the necessity for suitable tracking snow and a fairly abundant fox population. If foxes are absent or scarce, coyote tracking appears to offer comparable data. For example, during the winter of 1957–58, we located 18 deer carcasses on a 7-square-mile study area in the Upper Peninsula by following coyote trails 97 miles.

Easily recognizable boundaries of study areas are a distinct advantage. We were fortunate in this respect by having our areas well defined by roads or fences. If the investigator wishes to restrict his efforts to specific areas, it is usually not difficult to backtrack to where another fox has cut the original trail if the animal being followed leaves the study unit.

Robinette, *et al.* (1954, 1956) and Whitlock and Eberhardt (1956) have described methods for determining deer losses during the fall and winter. The fox-trailing technique cannot be applied to such large scale sampling, but the data we have collected at Gladwin and Rifle River indicate that by following as little as 16 miles of fox trails per square mile, fox trailers will find about 60 percent of the deer carcasses present.

We were positive that 46 of the 85 deer carcasses found on the study areas were shot illegally during the "bucks-only" season (November 15–30). We believe most of the unmarked deer located later also were illegally shot at the same time; but some of the unmarked carcasses found at Gladwin and Rifle River could have been deer shot by permit hunters during the any-deer seasons of December 1 and 2, and not found.

We set up the study at White Cloud primarily to eliminate this crippling-loss factor, since only antlered bucks were legal there, and all antlerless deer found shot had to be illegal kills. However, poor tracking conditions at White Cloud hampered fox trailers, and only 62 miles of fox tracks were followed on the 9-square-mile area.

Whether due to crippling loss or malicious shooting, the average annual waste of deer on the three study areas was calculated as 4.0 deer per square mile. Schofield (1958) and Jenkins and Bartlett (1959) further discuss the illegal drain from Michigan's deer herd.

Since only one buck with antlers longer than the 3-inch legal minimum was found by fox trailers in the entire fox–ruffed grouse study, we judged that the loss of crippled antlered bucks is slight on heavily hunted areas. The number of deer crippled by an individual hunter may be high, but with many hunters in the woods the chance of a badly crippled or dead buck not being found and salvaged must be slight. All other deer found were does, fawns, or "sub-legal" bucks. However, we have little information regarding crippling losses under our present system of any-deer hunting under permit.

CONCLUSIONS

1. The fox-trailing technique offers a suitable method for determining hunting season waste of deer on small areas.
2. The crippling loss of antlered bucks is low on heavily hunted areas.
3. The illegal kill of does and fawns under bucks-only regulations is high.
4. Additional studies of the crippling loss of deer during strictly any-deer seasons are needed.

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A CHART FOR ESTIMATION OF LIFE EXPECTANCY

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Life expectancy is a useful figure to help understand many problems in wildlife management. A precise estimate may not be required or possible because the cost of obtaining data may be excessive or the needs may not require high precision. Also, annual variability may be too great to justify using an estimate of high precision in predictions. Since it is often true that data on the probability of surviving can be more readily obtained than can data on life expectancy, this note presents a chart from which life expectancy can be determined when probability of surviving is known. Furthermore several procedures for calculating life expectancy are compared.

Life expectancy here has the conventional definition. It is the average number of years to be lived

in the future by the members of a population. It can be calculated by determining from a population the total years lived by the members till death and dividing by the number of members at the start of the age being considered. The starting date of age (Jan. 1, or birth, etc.) must be clearly stated. A simple example follows. Suppose that on Jan. 1 ($X = 0$) we have a population of 1,000 animals and that 80 percent die each year.

x	l_x	L_x	T_x	E_x (in time units)
0–1	1,000	600	750	750/1,000 = .75
1–2	200	120	150	150/200 = .75
2–3	40	24	30	30/40 = .75
3–4	8	5	6	6/8 = .75
4–5	2	1	1	—
5–6	1	0	0	—

where:

x is time interval in suitable units (usually a year);

l_x is number alive at start of each time interval;

L_x is an approximation to the average alive during time interval and is strictly the average of initial and final populations or $\frac{l_x + l_{x+1}}{2}$;

T_x is cumulated total of live individuals from end of column of L_x, which is the total number of years to be lived by L_x individuals. From this:

E_x is T_x/l_x, where E is called expectancy, as defined above. Naturally the expectancy is the same for each interval in this case because 80 percent die during each unit.

Another approach to life expectancy is available. We may define probability of dying as the number of individuals that die during a period of time divided by the initial population. Now when we have a constant and instantaneous probability we can state that:

$$\frac{\frac{d\,l_x}{dx}}{l_x} = -q \text{ where } \frac{d\,l_x}{dx}$$

is the change in number of living in an instant of time and l_x is the population. Hence $l_x = e^{-qx}$ which, when integrated from x to infinity, is $\frac{e^{-qx}}{q}$. This sum is the area under the survivorship curve.

Expectation of life is this area divided by the number of individuals or

$$E = \frac{\frac{e^{-qx}}{q}}{e^{-qx}} = \frac{1}{q}.$$

Thus the expectation of life is the reciprocal of the probability of dying.

Probability of surviving (p) is the number of individuals that survive divided by the initial number in the group, and is the complement of the probability of dying. The time interval (year, month, etc.) must be stated. The terms "death rate" and "mortality rate" are often used for probability of dying. Probability of surviving of individuals in a population can be obtained by a number of calculations (age composition, population changes, survival of individuals) and from it the life expectancy can be determined.

A third approach to life expectancy is available. If we define death rate as the number of deaths divided by the average population, we have a term comparable to the term birth rate (births per individual) that is useful in population studies. The two concepts (death rate and probability of dying) may be related by the familiar equation for the change in population: $N_t = N_0\, e^{rt}$, where N_t = population at time t, N_0 = initial population, e = base of natural logarithms, r = intrinsic rate of increase, t = time. Since r is birth rate minus death rate we can write, when $b = 0$ and $t = 1$, $\frac{N_t}{N_0} = e^{-d}$, and since by definition $p = \frac{N_t}{N_0}$, thus $p = e^{-d} = 1-q$.

From a table of natural logarithms, it can be seen that when p is high (more than 0.85), then d and q are very nearly equal. This approximation occurs because when survival is high, the initial population (which is the basis for derivation of q) very nearly equals the average population (which is the basis for d). A consequence of this solution is that when p is high we can use $d = q$ and state that $E = \frac{1}{q} = \frac{1}{d}$ as an approximation. Then $p = e^{-d} = e^{-1/E}$ or $E = \frac{-1}{ln\, p}$.

This equation automatically includes the complicated corrections suggested by Farner (1949). Indeed the equation $p = e^{-1/E}$ is identical to Farner's seventh equation: $Y = \frac{0.4343}{-log_{10}\, S}$, where Y is life expectancy (E), S is probability of survival (p). Hence $E = \frac{-0.4343}{log_{10}\, p} = -\frac{1}{ln\, p}$.

A major assumption in any study is that the probability of surviving is constant during each time unit. Since this rarely holds for wild species the estimate will be rough. Another assumption is that the probability of surviving is the same throughout the specified age interval of the individual. This assumption is relatively good for adult birds and some mammals but obviously not for young and old of various species.

For many years the formula of Burkitt (1926) has been used. It is usually stated that $Y = \frac{2-m}{2m}$ where Y equals life expectancy (E) and m equals "mortality rate" which is actually probability of dying (q) during a year. Now the number of deaths, k, during the year is $N_0 q$ where N_0 is the

initial population. Thus $E = \frac{2-q}{2q} = \frac{2N_0 - N_0 q}{2N_0 q} = \frac{2N_0 - k}{2k} = \frac{N_0 + N_0 - k}{2k}$. Now since the population N_t at time t is $N_0 - k$, then $E = \frac{N_0 + N_t}{2k}$. This can be written as

$$E = \frac{\frac{N_0 + N_t}{2}}{k}$$

which states that the expectation of life equals the average population divided by the deaths. Since this is the reciprocal of d then $E = \frac{1}{d}$. Thus Burkitt's formula can only be used when p is high as explained below.

It is desirable to return to the life table given at the start. This table was made brief for simplicity of explanation and thus has a high value for q. High values, we have just seen, lead to distortions. The reason is that when time intervals are long, then $\frac{l_x + l_{x+1}}{2}$ is *not* a good estimate of the average population. If we apply these ideas to the life table we find that when $p = 0.2$ then $d = 1.609$ and $E = 1/d = 0.62$ rather than $E = 0.75$. Thus for high values of q the life table is not the best estimate but the values derived from $E = 1/d$ are better.

Haldane (1955) derives a formula for estimating q from deaths in successive years, using the maximum likelihood method that is identical to Farner's first formula, namely $M = \frac{D_1 + D_2 + D_3 \ldots}{D_1 + 2D_2 + 3D_3 \ldots}$, where Farner's M is probability of dying (q) and D refers to the number of deaths at various ages. This is rewritten by Haldane as: $q = \frac{D}{x\,D_x}$, where x is the age. Haldane also points out that since the standard error of proportions is $\sqrt{\frac{pq}{n}}$ where $n = x\,D_x$, then, by algebraic manipulation, S.E. $= q\sqrt{\frac{p}{D}}$.

A plot (Fig. 1) of the three methods illustrates the various curves. The heavy line gives the expectancy calculated from actual data as illustrated in the table above. Constant proportions of deaths in each year are the basis for plotting.

The dashed line gives the points derived from $E = 1/q$. It is clear that the values agree with the calculated expectancies (heavy line) only for very low values of q. Eventually the biologically absurd relation occurs when $q = 1$, $E = 1$, or, as stated by Farner (1949), every individual dies on the last day of the year. Thus this relation is rarely useful in biological work. The basis of the failure is simply the fact that when q is high $\frac{l_x + l_{x+1}}{2}$ is not a good estimate of the average population.

The light line gives the points derived from $E = \frac{1}{d} = -\frac{1}{\ln p}$. It is clear that the values will agree well with the calculated expectancies (heavy

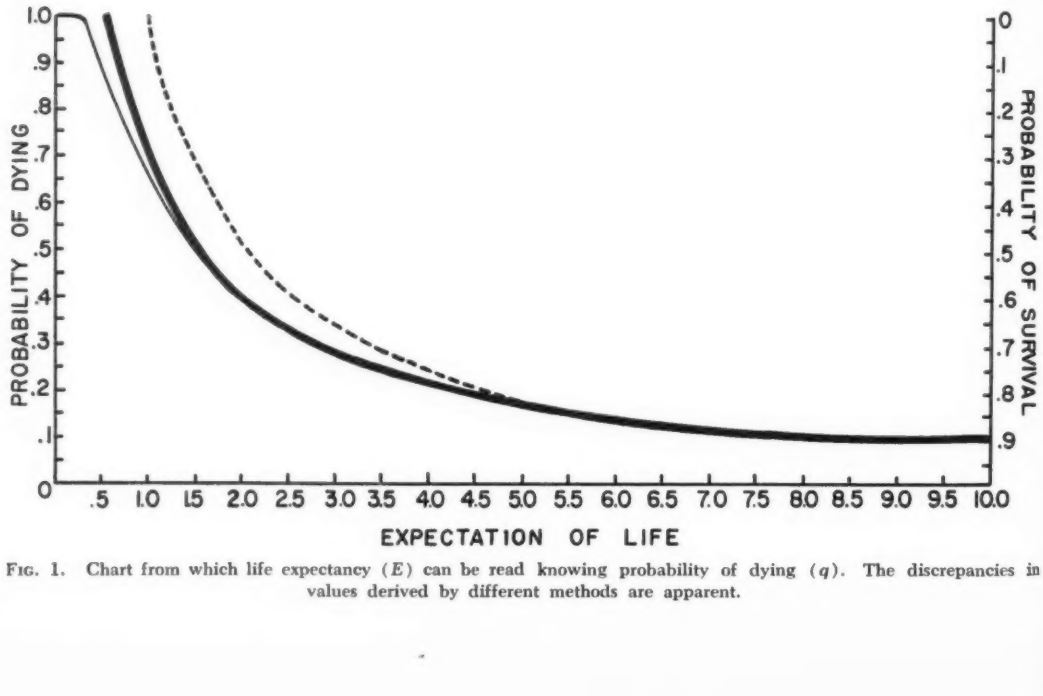

FIG. 1. Chart from which life expectancy (E) can be read knowing probability of dying (q). The discrepancies in values derived by different methods are apparent.

TABLE 1.—COMPARISON OF OBSERVED AND CALCULATED LIFE EXPECTANCIES

x (age)	d_x (number dying)	q_x (probability of dying)	E_x (from Olsson)	$E_q = \frac{1}{q}$	$d = -\ln p$	$E_d = \frac{1}{d}$
0–1	670	0.670	1.70	1.49	1.11	0.900
1–2	126	0.382	3.14	2.62	0.48	2.08
2–3	64	0.314	3.77	3.19	0.38	2.53
3–4	37	0.264	4.26	3.78	0.31	3.22
4–5	26	0.252	4.62	3.96	—	—
5–6	21	0.273	5.01	3.68	—	—
6–7	13	0.232	5.70	4.31	0.27	3.70
7–8	6	0.140	6.27	7.15	0.15	6.67

line) until values of q reach about 0.5. Eventually the biologically absurd relation occurs that when $q = 1$, $E = 0$, or, no individual lives. The reason that agreement is good between E from observations and E from $1/d$ derives from the relation of average population and total years lived. Burkitt's formula thus is satisfactory when q is less than 0.5. Luckily, birds (for which the formula has been used) have such values and thus no serious error occurred.

An example may help to illustrate the problems. Data (Olsson, 1959) on recoveries of 910 grey herons from Scandinavia are given in abbreviated form in Table 1. Merely for simplicity, 33 individuals more than 8 years old at death are omitted as well as some calculations. The observed values of E_x illustrate the point that mortality varies each year and thus the observed values for the history of the population change.

E_q derived from the reciprocal of q varies because it is obtained from the value for each year but assumes a constant value of q for the life of the population. It is generally lower than observed because the value of q declines especially for herons more than 8 years old (omitted from table).

E_d derived from the reciprocal of d also varies and differs from the observed E_x for the same reasons as above. E_d differs from E_q when q is large as explained above. However, when q is small, the values of E_q and E_d differ less than the errors of measurement that might be expected. The values of the half-life could be calculated from any value for E.

This example makes clear the problems arising from the assumption of constant rates in the calculation of E. The observed values of E make no such assumptions but have limited generality and predictability.

An example may illustrate the use of the chart (Fig. 1). Studies of gray foxes (Wood, 1958) showed that for young foxes, $q = 0.7$, and for adults, $q = 0.5$. The life expectancies can be read from the graph to be about 1.0 and 1.5 years respectively.

This chart will be useful for rough estimates desired for prediction or generalized statements but it is no substitute for the careful determination of life expectancy from adequate data.

The chart has potential use in determination of natural mortality in populations whose mortality due to hunting is known. Suppose that the probability of dying from hunting was 0.18 and that the age composition of the animals showed that the expectancy was 2.0. Obviously some natural mortality is occurring because when $q = 0.18$, the expectancy, as read from the chart, is 5.0. The procedure is to determine the natural mortality in terms of q. When expectancy is 2.0, then $q = 0.40$ (from the chart) and $p = 0.60$. Since the values for q cannot be manipulated (an animal cannot die more than once but can survive for more than one time-period), the value of p must be determined. Since probabilities must be multiplied we have $(p_h)\ (p_n) = p_t$ where:

p_h is probability of hunting survival or 0.82;
p_n is probability of natural survival;
p_t is probability of total survival or 0.60.

Hence $p_n = \dfrac{0.60}{0.82} = 0.74$ and $q_n = .26$.

This easy separation of natural and hunting mortality should permit a test of the effect of increased cropping. If the hunting mortality increases but the expectancy remains the same, then hunting deaths are replacing natural deaths. Note that it is not necessary that the hunting and natural mortalities should be simultaneous. The hunting mortality can occur during a short season and the natural mortality during a year.

It may be of interest to relate life expectancy to the time required for half the population to die. This time is, of course, the "half-life" used in discussions of radioactive decay and is convenient for comparisons since 50 percent points ("half-life") lend themselves to statistical tests. Using: $\dfrac{N_t}{N_0} = e^{-dt} = p$, when N_t is one-half of N_0, then $p = 0.5$ and hence $\ln .5 = -dt$ where t is time for half to die, and thus $t = \dfrac{0.7}{d}$.

Since at values of $q = 0.5$ (see graph) d is approximately equal to $1/E$, then while p is constant, the time required for half a population to die is $.7E$. Similarly the time for three-fourths to die is $1.4E$. A graph could easily be prepared to show at a glance the value of t at any value of E.

SUMMARY

The relations among the definitions of life expectancy, probability of dying, and death rate are analyzed and presented in a graph. The assumptions and approximations lead to certain restrictions in these relations. A method is suggested for partitioning mortality into "natural" and "hunting." Furthermore the relation of "half-life" to life expectancy is determined.

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THE NEED FOR DIFFERENTIATION OF TRICHOMONIASIS AND POX INFECTION IN DOVES

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Trichomoniasis, a disease caused by a flagellated protozoan (*Trichomonas gallinae*), was first reported from mourning doves in North America in 1924. Since then the infection has been reported in doves from many areas in the United States and severe losses have been noted in some regions.

The most characteristic lesions of trichomoniasis occur in the mouth, in the early stages as small yellow spots, in advanced cases as large lumps of yellowish, cheesy but firm, material which ultimately may occlude the passage of food or air, causing starvation or suffocation. Occasionally an infected bird develops externally visible lesions that appear as swellings on the neck or involve the eye.

Transmission of *T. gallinae* from infected parent to offspring occurs in the natural feeding process. It also can pass from infected adults to other susceptible doves in contaminated food or water. Dove biologists are aware of the possible occurrence of trichomoniasis. Studies are in progress in several areas of the country to learn more of its biology and possible control.

A disease known as pox may exhibit gross pathology similar to that produced by trichomoniasis although it has not been recognized as an important disease in doves. Recently several outbreaks have been reported in mourning doves (Kossack and Hanson, 1954; Locke, *et al.*, 1960). The severity of these outbreaks suggests that pox infection may be an important cause of dove losses in many areas. We believe that wildlife biologists not familiar with the lesions of pox infection occasionally may have misidentified pox lesions as those of trichomoniasis. Many outbreaks of unconfirmed etiology, but suggestive of pox rather than trichomoniasis, have come to our attention.

Pox is a viral disease attacking several species of birds. It is a highly contagious disease that spreads rapidly among a group of susceptible birds. Although the virus is unable to penetrate unbroken skin, most birds have small injuries that allow the virus to gain access to host tissue. Mosquitoes and gnats (*Culicoides* sp.) are reported to transmit pox infection.

A cutaneous form of pox in the mourning dove is characterized by the development of variable-sized nodules upon the head and legs. Nodules are most common about the eyes, base of the bill, and upon the top of the head. The cutaneous nodules vary in size from 1 × 2 mm. thickenings of the lower eyelid to large spherical pea-sized growths that occlude the eye.

A diphtheritic form of pox is characterized by the production of small, yellowish, roughly diamond-shaped lesions in the back of the mouth. These small lesions may coalesce to form a large, yellowish, cheesy mass. This mass closely resembles the lesions found in the later stages of trichomoniasis. Laboratory procedures are necessary to differentiate the diphtheritic form of pox from trichomonad infection. The cutaneous form of pox is more readily recognizable in the field. However, in all cases laboratory confirmation is desirable.

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OBITUARIES

William R. Rawlings
1924–1959

William R. Rawlings of Durango, Colorado, a member of the Central Mountains and Plains Section of The Wildlife Society, died July 9, 1959, from head injuries suffered when the horse he was riding was struck by a truck.

The San Juan National Forest supports game animals of many species, and Bill, as a member of the supervisor's staff, was developing wildlife habitat improvements to maintain this important resource. In addition to big game range betterment he was seeking some hardy high altitude shrub for living fences—something more favorable to wildlife than the 4-strand barbed wire of western livestock ranges. He also found time to teach ornithology at Fort Lewis A. & M. College at Durango.

Bill is survived by his mother, his wife Mary Ann, and four children. He served with the Sea-bees for 2½ years in World War II. A graduate of Wilbraham Academy, he also attended Harvard University. He received his B.A. degree from the University of New Hampshire in 1950 with a major in history. Following graduate work at American International College he received his B.S. degree in wildlife management from Iowa State College in 1954. He returned to the University of New Hampshire where he earned his M. F. degree in 1956. He had aspirations to continue studies for a Ph.D. degree in wildlife management. He was a member of the American Society of Mammalogists and the American Society of Range Management.

Coming from the eastern part of the country, he taught the need for intensive and coordinated management of resources that many westerners take for granted. His enthusiasm in the wildlife management field was an inspiration to all those who worked and associated with him.—Ralph R. Hill.

Laurence M. Dickerson
1899–1959

Dr. Laurence M. Dickerson, Biology Specialist with the Soil Conservation Service at Charlottesville, Virginia, passed away on June 15, 1959, after an extended illness. He was born at Cadiz, Ohio, June 26, 1899. He attended high school at Fredericksburg, Virginia, and received his B.S. degree in biology from the College of William and Mary in 1924. In 1928 he received his M.S. in biology from the University of Virginia, followed by his Ph.D. from the same institution in 1930.

Dr. Dickerson was a research assistant in the Department of Biology at William and Mary College from 1922 to 1924. From 1924 to 1926 he taught science at Shepherdstown, West Virginia. The following year he taught biology at Newport News High School, Newport News, Virginia. After receiving his doctorate in 1930, he became professor of biology at Cumberland University, Lebanon, Tennessee, where he stayed until 1935. In 1935 he was appointed as a Wildlife Technician in the National Park Service, Atlanta, Georgia. In 1936 he transferred to Oklahoma City, in 1937 to San Francisco, California, and in 1938 to Richmond, Virginia, all with the National Park Service.

In November of 1938, he became regional biologist for the Soil Conservation Service at Dayton, Ohio. Following a reorganization, he transferred to Spartanburg, South Carolina as a Soil Conservationist, where he remained until 1951. From 1951 until his death he served as biology specialist for the Soil Conservation Service in Virginia.

He had seven publications, including "The Problem of Wildlife Destruction by Automobile Traffic" in the Journal of Wildlife Management, April 1939.

He was affiliated with Phi Beta Kappa, Sigma Xi, Chi Beta Phi, Pi Gamma Mu, AAAS, Virginia Academy of Science, Tennessee Academy of Science, Ohio Academy of Science, Wildlife Society, Soil Conservation Society of America, and the American Genetic Association.

He is survived by his wife, Arline, of Covesville, Virginia, two sons, Laurence W. Dickerson of Erwin, Tennessee, and Charlesworth L. Dickerson of Racine, Wisconsin, and a daughter, Mrs. Marianna Dickerson Minter, of Columbia, South Carolina.

"Doc," as he was familiarly known to his associates, was a man of integrity, and his quiet, sincere manner earned him the confidence of his fellow workers. He was tireless in his devotion to his profession and loved nothing better than to discuss the virtues of a good farm wildlife program. Many are the young conservationists who have a better understanding of wildlife management because they were privileged to work and talk with "Doc." Their future accomplishments in developing farm wildlife programs will serve as a living monument to the memory of our beloved fellow conservationist. —Frank F. Carr.

Floyd Lavinius Parks
1896–1959

Lt. Gen. Floyd Lavinius Parks, USA, Ret., died March 10, 1959, at Walter Reed Hospital in Washington, D.C., after a lingering illness. At the time of his death General Parks was Executive Director of the National Rifle Association of America, a position he accepted upon his retirement from the army in February 1956.

Born in Louisville, Kentucky on February 9, 1896, General Parks had a 38-year military career during which he served with distinction in many posts throughout the world and in the United States.

General Parks graduated from Clemson College in South Carolina in 1918 with the degree of Bachelor of Science and immediately entered the army as a private. He was commissioned the same year

and was assigned to the 65th Engineers, the original Tanks Corps unit in this country, under the command of the then Capt. Dwight D. Eisenhower who remained a close personal friend and golfing partner throughout the rest of the general's life. General Parks received a M.S. in Mechanical Engineering from Yale University in 1924.

The many military posts General Parks had during his long and active career included Army Chief of Staff of Ground Forces (1942); Chief of Staff, First Allied Airborne Army (1944); Commanding General of the United States Sector, Berlin District (1945); Chief of Public Information for the War Department (1946 and 1949); Deputy Commander, U.S. Army, Pacific (1948); and Commanding General, 2nd Army (1953).

General Parks is survived by his wife, the former Miss Harriet Marie Applebye-Robinson; his daughter, Mrs. Richard C. Strain, of Poughkeepsie, New York; and three sons, Lt. William Robinson Parks, Basil Many Parks, II, and Floyd Lavinius Parks, Jr.—DANIEL A. POOLE.

LAURENCE H. RUBKE
1908–1959

The California Department of Fish and Game lost an important member of its wildlife management team with the passing of Laurence H. Rubke, member of the Wildlife Society, on September 28, 1959. Mr. Rubke had held a number of important management jobs for the California department during his 18 years of service. He had been largely responsible for the development and management of the Imperial Waterfowl Management Area at Brawley. In more recent years, he had been assigned to duties of manager in charge of the Grizzly Island Waterfowl Management Area in the Suisun Marshes. Mr. Rubke was an expert in manipulating California waterfowl and pheasant habitat to the advantage of the State's and the nation's wildlife. He felt very deeply the obligation of furnishing public shooting to California's unattached hunters.

Laurence suffered a heart attack while returning from a field assignment in connection with California's 1959 deer season. His passing was regretted by all his friends in the wildlife field and particularly his associates in the California Department of Fish and Game.—BEN GLADING.

ARTHUR WILBUR HENN
1890–1959

Dr. Arthur W. Henn died in Winter Park, Florida on May 8, 1959, bringing to a close an active life devoted to the field of conservation.

Dr. Henn was born on March 8, 1890 in Evansville, Indiana. He attended Indiana University, receiving the degree of Bachelor of Arts in 1914 and the degree Master of Arts in 1915. From 1915 to 1917, he attended Columbia University. He was awarded an honorary Doctor of Science degree from Westminster College (New Wilmington, Pa.) in 1937.

An early interest in animal life is indicated by the fact that Dr. Henn was an Assistant Zoologist with the Chicago Field Museum of Natural History from 1909 to 1911. From 1912 to 1914, he served as leader of the Landon Expedition sponsored by Indiana University to make fish surveys and collections in the Andes of Columbia and Ecuador. After returning from an 18-month overseas tour with the 82nd Division during World War I, Dr. Henn was appointed Associate Ichthyologist, American Museum of Natural History, a post which he held from 1919 to 1922. He was made Curator of the Carnegie Institute Museum, Pittsburgh, Pennsylvania in 1922 and served as editor of its publications from 1936 until his retirement in January, 1951. Perhaps his most outstanding contribution to the field of biology was his part as associate editor of the *Bibliography of Fishes*, to which Dr. Henn devoted much of his time and personal data.

Dr. Henn belonged to many professional organizations, including the following: American Society of Ichthyology and Herpetology, American Society of Mammalogists, American Fisheries Society, Pittsburgh Zoological Society, Pennsylvania Academy of Science, New York Academy of Science, National Audubon Society, The Wilderness Society, Izaak Walton League of America, and others. During his office as secretary of the Pittsburgh Zoological Society beginning in 1935, Dr. Henn was responsible for the reactivation of the city's zoo in Highland Park.

Everyone who knew Dr. Henn will remember him for his inexhaustible energy, his devotion to his work, his congenial personality, and his readiness to give aid to others. The biology profession can justly mourn the passing of someone as capable and energetic as was Dr. Henn.—S. L. BECKWITH.

WALTER BIGLER KIENER
1894–1959

Dr. Walter Bigler Kiener passed away August 24, 1959, at Lincoln, Nebraska. With his death, the conservation profession lost a noted writer and lecturer on subjects ranging from aquatic biology to alpine vegetation.

Born on October 18, 1894, at Berne, Switzerland, Dr. Kiener early found an interest in mountaineering which eventually led him to the study of alpine natural history. According to tradition, however, he was first apprenticed to his father, who owned a small butcher shop and sausage making business. He helped his father provide for a large family, but attended night classes tc supplement his formal education.

In 1922, Dr. Kiener came to the United States. He worked in a New York packing house, but 7 months later he moved to Denver to be near the mountains. Here he worked in a small sausage plant, spent his weekends in the mountains and attended evening classes in citizenship and English.

In 1925, Dr. Keiner was involved in a mountain

rescue attempt, losing parts of his fingers and feet. This ended his trade career and in the following 5 years he was a U.S. ranger in the Rocky Mountain National Park. During this time he met many professional people who, hearing of his rescue attempt and subsequent loss, urged him to continue his education.

He enrolled in the University of Nebraska as a special student. At this time he became a naturalized citizen. From his photographs of both the Swiss Alps and the Colorado Rockies, he made lantern slides, from which he lectured extensively for many years. In 1930, Dr. Kiener received his AB degree and a year later he obtained his master's degree. He received his doctorate in 1940 from the University of Nebraska.

In the early 1930's, Dr. Kiener chose a phase of alpine vegetation on Long's Peak for his particular investigation. This pioneer work stimulated him to collect and study lichens outside the alpine zone. His home was made into a workshop for natural history studies where he had an extensive herbarium of lichen specimens covering over 20 years of work and study.

He was credited with the founding of the fishery research program of the Nebraska Game, Fish and Parks Department, and made many contributions on the ecology of alpine vegetation and on limnology of Nebraska waters.—LEONARD E. FOOTE.

BOOK REVIEWS

Wildlife Conservation. Second Edition. By Ira N. Gabrielson. Macmillan Co., New York. 1959. 244 pp., 32 plates, 23 figs. $5.50.

This is the second edition of a book that first appeared in 1941. The aim of both editions was to promote a broad program in conservation. In general, major emphasis is on America's living natural resources, including plants and wildlife. Most references to specific examples are drawn from the Midwest and West. As a region, the Southeast seems slighted.

The author has attempted to bring the subject matter up to date and has added to the current edition a new chapter dealing with "Wildlife on Agricultural Lands." Maps showing the four flyways in North America have also been added. The format has been greatly improved and the plates and figures are of good quality and choice.

Basically, the book consists of relatively well-known and simple facts organized to explain wildlife conservation problems. It represents a good job of weaving the many facets of conservation into a workable plan. It has considerable repetition in several chapters, but the nature of the "web of conservation" makes this treatment quite necessary. The effect of the repetition is to emphasize basic points and interrelationships.

Content includes chapters on soil and wildlife, water conservation, life of the waters, forest conservation, forestry and wildlife, wildlife and agriculture, grassland and wildlife, resident game, migratory birds, fur animals, non-game birds and mammals, rare and vanishing species, predators, wildlife refuges, and some related topics.

The author seems to have oversimplified problems with deer in the Southeast, placing most of the blame for locally limited populations on overhunting. He intimates little lack of food there, but makes no mention of lack of quality food, nor the recurring die-offs due to disease, nor the rather recent local decimations due to screw-worms. A reference to quail-shooting preserves in the "Southwest" (p. 119) probably refers to the Southeast or at least should include that region, where quail preserves are common. On some issues the author apparently has taken a sort of middle-of-the-road stand and left it up to the reader to make up his own mind as to what is the best approach. In the discussion on fire, he recognizes the possible use of fire as a management tool, but in conclusion speaks of fire as a great enemy when he really should say wild fire.

It was refreshing to see his evaluation of the limited usefulness of game farms for already established species. His remedies for obstacles to progress in wildlife conservation are well taken, and include: alert and intelligent local conservation groups, an increase in percentage of public that understands conservation, increased and improved conservation education, increased research, better land use with consideration for all resources, and environmental restoration.

Those who have read the earlier edition will find the current one a refreshing review. Those who read the new "Wildlife Conservation" will find it stimulating and an aid to better understanding of conservation principles. The book should have its greatest usefulness for teachers, urban and rural sportsmen, and conservation workers, including soil conservation farm planners.—ARNOLD O. HAUGEN, Iowa State University, Ames, Iowa.

A Natural History of New York City. By John Kieran. Houghton Mifflin Company, Boston. 1959. 406pp., illus. $5.75.

Man's influence in changing wilderness has led Charles Elton, well-known British ecologist, to claim that "in another thousand years most of the world's surface and much of its fresh water will have been altered and fashioned by man, or at any rate covered with living communities of plants and

animals profoundly different from what they were even a few hundred years ago." (Elton, Charles. 1958. The Ecology of Invasions of Plants and Animals. John Wiley & Sons Inc., New York.)

This observation is Elton's point of departure in calling for an orderly and planned coexistence between man and nature. Ecologists can and should lead the way in analyzing and interpreting for the public the important changes that are occurring in plant and animal communities as a result of urbanization, monoculture agriculture and other changes in our landscape. Changes are occurring so rapidly, however, that we must satisfy ourselves with progress reports and hopeful forecasts. Only when the pressure of population increase has relaxed, Elton states, will we be able to decide whether or not man has been able to achieve an harmonious state of balance with nature or his environment. But it is not ecologists alone who provide us with information on these matters. The strived-for coexistence is nurtured by many points of view, among which is the belief that nature is interesting and beautiful, something that should be preserved, studied and enjoyed in spare hours.

John Kieran, layman author of many successful books on nature and for 12 years a panelist on the well-known radio program, *Information Please*, has published an account of the wealth of nature still to be found in New York City. In what is commonly considered to be the most highly developed and completely paved area known to the world, Mr. Kieran has found material for over 400 pages of nature lore. The major changes in wildlife for the New York City area, as he sees them, are primarily in quantity, not in kind. His outstanding fund of knowledge is combined with a skill of writing that makes the lowliest forms of animal and plant life found in a cup of pond water as interesting and exciting as the peregrine falcon, often seen chasing pigeons through the manmade canyons of Manhattan. Students of nature who have developed specialized interests will be amazed at the specific knowledge displayed by Mr. Kieran, especially when viewed in light of the complete spectrum of nature presented from the bedrock geology of New York City through the plant and animal kingdoms.

Limiting factors of extent and depth of material in the book, Mr. Kieran writes, are "the author's ignorance and the reader's patience," both to be seriously doubted. However, one might wish that Mr. Kieran had devoted one chapter to the interrelationships between the various orders of plants and animals that he writes about in so winning a fashion, and perhaps another to the need for maintaining open spaces and a diversified landscape to preserve a variety of wildlife. One fears that the casual reader will gain the impression that Mr. Kieran believes a *laissez-faire* attitude will satisfy all the needs of wildlife in a rapidly expanding megalopolis. The statement, "no one will live long enough to learn all there is to know about the wildlife that exists in the great city," gives the impression of an abundance and diversity of wildlife maintaining itself and in no need of protection and concern.

Indeed, there is evidence that this is a commonly held belief in the New York metropolitan region. Public agencies have not yet established an adequate program for open space. The Regional Plan Association, which recently initiated a project to study problems of parks, recreation and open space, has found that "there are no serious legal obstacles to a program for acquiring and preserving open space in the Tri-State New York Metropolitan Region . . . More authority exists to accomplish an open space objective than most public agencies are themselves aware." (Siegel, Shirley A. 1960. The Law of Open Space. Regional Plan Association, 230 W. 41st. Street. New York City.)

Why is it, then, if we have legal means, that we do not have adequate planning and action for maintenance of open space in New York City and other highly urbanized centers—open areas that would diversify the landscape and provide habitat for a wide variety of plant and animal life? Partly, it is because of complacency (or reluctance to act) based on observations such as Mr. Kieran's that communities of plants and animals remain in spite of extensive blanketing of an area with pavements and buildings. Partly, it is because no single group, ecologists, wildlife managers or any other, has given strong enough arguments in favor of a program for preserving a diversified landscape.

The two arguments usually stated are focused on the aesthetic appeal of open areas and the accepted need for maintaining wildlife in refuges and sanctuaries. The Regional Plan Association's report gives additional arguments involving watershed protection and flood prevention. Even these do not appear to be sufficient in light of competing economic uses for space in metropolitan areas and the possibilities for solving many local conservation problems through adequate civil engineering.

Wildlife students and enthusiasts interested in this problem may want to refer to Charles Elton's book, especially the two chapters entitled "The Reason for Conservation" and "Conservation of Variety." Here they will find an additional argument. Elton's thesis is that we can keep our biological affairs in order only if we maintain complex and varied wildlife communities. His argument for maintaining open space and a diversified landscape is based on the need to promote a stability in which all kinds of compensatory pressures (biotic) will be exercised on local plant and animal communities. Stability is difficult to maintain where the landscape is progressively simplified.

For rural areas, this argument makes sense if illustrated with case histories of insect and plant disease problems (in orchards and single crop farming) where eruptions are encouraged by elimination of natural checks. For urbanized areas, the best case histories so far documented have to do with epidemics and plagues. Much more evidence is needed, Elton claims, to substantiate this argument.

In spite of this single shortcoming of Mr. Kieran's

book—inadequate interpretation of the significance of changes in composition and structure of wildlife—*A Natural History of New York City* will do much to stimulate interest in New York's out-of-doors. Mr. Kieran's book not only serves as a field guide for location and identification, but is extremely literate as well (as one might expect from so well-rounded a man). After finishing a first reading, and many returns are foreseen, one might well hope, as Mr. Kieran quotes, to:

"Have sight of Proteus rising from the sea;
Or hear old Triton blow his wreathéd horn."

—WALLACE D. BOWMAN, Conservation Foundation, New York City and GEORGE LAMB, Manager, Tinicum Wildlife Preserve, Department of Recreation, City of Philadelphia.

The Wild Mammals of Missouri. By Charles W. and Elizabeth R. Schwartz. University of Missouri Press and Missouri Conservation Commission. Printed at Kansas City, Missouri. 1959. vii+341pp. 57 plates and numerous figures. $5.95.

This book brings further distinction to a husband-and-wife team of biologists already internationally known for their bird and mammal research as well as for fine artistry with brush and camera. *The Wild Mammals of Missouri* is a semi-technical work, as judged by the wealth of detail given on structure, adaptations, and habits of the species discussed. But it is distinctly popular in the abundant illustrations, the avoidance of technical terms, and the compact ease of its descriptions. Any intelligent reader will need only his interest in animal life to find keen satisfaction in this thoroughly competent work. I believe its range of usefulness is about as broad as can be achieved in this field.

The book is built around the accounts of 47 species of mammals which were published in abstract, with their plates, in the *Missouri Conservationist* from 1953 to 1957. Much material has been added, and the completed work treats 62 species known to be established in the State, 5 formerly occurring there, and 13 which may be present, though unrecorded or known from incidental specimens.

The first of the nine chapters (numbered only in the Table of Contents) is entitled "Introducing the Mammals." It treats briefly the place in nature, economics, and esthetics of this class of animals and gives a general description of environmental adjustments, reproduction, and physical characteristics. The significance of tooth structure and the use of tooth formulae are included. The geographic regions of Missouri—Prairie, Ozark Highland, and Mississippi Lowland—are described by word, map, and photographs. The reader is shown (by sketches) how to measure a mammal specimen; he is given a basic lesson in taxonomy and a key to orders. Each of the chapters to follow covers a single order and includes two dichotomous keys to species—one based on the whole specimen in the flesh and the other on skulls of adults.

In its attention to problems which commonly confront the student, the first chapter sets a pattern for the book. The 57 full-page plates portray the living animal in a natural situation, two or three views of the skull, and the feet. Identification points are labeled and frequently illustrated separately with enlarged sketches. Such features include the "W" pattern on cheek teeth of shrews and bats, structure of the tragus, calcar, and keel in bats, the four incisors and rostral network of lagomorphs, cheek pouches of burrowing rodents, the vestigial premolar of the gray squirrel, grooved incisors in several rodents, cranial ridge patterns in foxes, the double claw of the beaver, and many others. The grinding surface of the cheek teeth of rodents is always difficult to illustrate and is of critical importance in taxonomy. The Schwartz sketches show the various patterns at a glance and better than any other work I have seen. Age criteria are explained and illustrated to the extent that such information is available. There are drawings to show the disappearance of the epiphyseal groove from the humerus of the cottontail and the emergence of the first upper molar of the muskrat. Two full pages of sketches illustrate dental changes for different age classes of the white-tailed deer. A full-page plate is likewise devoted to the structure of the marsupium, mastology, and development of the young of the opossum.

In the accounts of individual species, repetition is avoided by describing a common, type animal first and referring to these detailed discussions in dealing with the closely related forms immediately following. For example, the little brown bat is treated fully as typical of the genus *Myotis*. The Schwartzes have, no doubt wisely, assumed no commitment for defining the subspecies of Missouri mammals. They have chosen a single, common name for each species, the distribution of which in North America is shown by shading on a reduced map. This system suits their purpose well, although it occasionally involves compromises disturbing to the professional. For example, in Missouri *Peromyscus maniculatus* (not designated, of course, as subspecies *bairdi*) is the "prairie white-footed mouse," and the range map applying to the many races of *maniculatus* shows the prairie white-footed mouse as occurring over the greater part of the continent.

The species accounts are compiled systematically, each beginning with the derivation of the scientific name. The standardized subject headings deal with a detailed description (including color, measurements, teeth and skull, sex and age criteria, glands, voice and sounds), distribution and abundance, habitat and home, habits, foods, reproduction, "some adverse factors" (predators and disease), importance, and management or control. This part of the text makes excellent use of the literature, but it also includes many interesting and useful sidelights which bespeak the personal ex-

perience of the authors. Facts on life history and field characters are brought out vividly by many pen sketches depicting animal activity, dens and nests, and tracks. This pen work adds much to the attractiveness of the book, even though it undoubtedly has lost detail in the reduction process. At the end of each species account is a list of the most significant literature.

The Wild Mammals of Missouri is a well-balanced and impressive work. It is firmly grounded in basic biology, it repeatedly demonstrates the ecological awareness of its authors, and the applications of fact to management are not forgotten. If the art work of Charles Schwartz were not previously known, this book alone would place him in the forefront of American wildlife illustrators. The nearly 400 drawings are done with a tasteful restraint and sure-footed mastery of technique that is altogether satisfying.

The publication of this book shows administrative courage and imagination. It is printed on good paper, well bound, and features a Schwartz oil painting in full color (the white-tailed deer) on the frontispiece. The University of Missouri Press and the Missouri Conservation Commission have cooperated to give this volume to the public at cost. As a commercial publication its price undoubtedly would be doubled. It is a "best buy" and to be recommended in every respect.—DURWARD L. ALLEN, Department of Forestry and Conservation, Purdue University, Lafayette, Indiana.

Fundamentals of Ornithology. By Josselyn Van Tyne and Andrew J. Berger. John Wiley & Sons, Inc., New York. 1959. x+624 pp. $11.75.

The book begins with a chapter on paleontologic facts about birds and the difficulties of tracing their earliest origins. The following 11 chapters are on anatomy, plumage and molt, senses and behavior, voice and sound production, bird distribution, migration, flight, food and feeding habits, breeding behavior, social relations, and taxonomy and nomenclature. The thirteenth and last chapter, comprising nearly one-third of the text, presents the classification of the birds of the world by families. Each of the 168 currently recognized families is represented by an inimitable pen-and-ink drawing by George M. Sutton. Information is summarized for each family on a single page, irrespective of whether the family consists of 3 or 300 species, and includes physical characteristics, range, habits, food, breeding, classification, and references. The number of species in each family is given, but they are not listed since emphasis in this last chapter, and throughout the book, is directed toward presentation of comparative data relevant to the families of the birds of the world.

The scholarly work of Josselyn Van Tyne, as an American ornithologist with an international reputation, is indicated clearly by his attention to detail, scientific accuracy of writing, and evaluation of trends in ornithological research. These attributes plus his wide acquaintance among amateur and professional ornithologists will result in the adoption of this book by many colleges for courses in ornithology. Although Van Tyne and Berger have designed their book primarily as a text for courses in ornithology, it will be valuable as a reference on all the families of birds; a dictionary of ornithological terms; a directive for persons interested in life history, taxonomy, and anatomy; a summary of features used in classification; and as a guide to ornithological literature.

The reader will welcome the list of references at the end of each chapter. Selected reference materials are also listed at the end of the book, and there is a comprehensive and usable index. Most of the references were published prior to 1956; a few are dated since that time. As a wildlife investigator I was disappointed in the conspicuous paucity of references to contributions from the field of wildlife management, particularly avian ecology.

Berger, in writing the preface to this book, states that ". . . some important subjects (e.g., physiology, genetics, ecology, study methods) had to be mentioned very briefly where pertinent in several chapters, and still other subjects (conservation, game management, population dynamics, museum techniques) not at all." Although these omissions were "necessary and intentional," I suggest that their omission and the advanced stage which other phases of research have reached indicate the current needs and probable trend of future research. It is almost certain that there will be relatively few major contributions forthcoming in subjects such as taxonomy, classification, and anatomy, whereas those pertaining to physiology and ecology will provide badly needed information on the functional aspects of ornithology.—IRVEN O. BUSS, Zoology Department, Washington State University, Pullman, Washington.

Recreational Use of Wild Lands. By C. Frank Brockman. McGraw-Hill, New York, 1959. xii+346pp. $8.50.

Here is the first book in a difficult-to-explore segment of natural resource use. Need for a book devoted exclusively to wildland recreation has often been expressed during the past 25 years. There are two reasons. (1) Many colleges and universities have inaugurated courses in "forest recreation," often in conjunction with wildlife management curricula. (2) Wildlife managers increasingly realize that wildlife becomes, acceleratedly, a part of a great outdoor recreation complex. Only recently the director of a western state game and fish department, when cooperating in planning public use for a new reservoir, declared, "We aren't in the recreation business!" The reply was, "Well, if game and fish aren't recreational resources, what do you think they are—a cross between a meat market and a bingo party?"

The wildlife manager benefits from reading Brockman's book in three principal ways. (1) He can orient the growing importance of wildlife management with the tremendous expansion of all recreation during the past century. (2) His memory of the book, combined with its logical arrangement and detailed index, can lead him back to events and policies he must understand when he perforce deals with various federal and state land-management agencies. (3) He becomes acquainted with related recreational professions which will be his strongest allies in unavoidable contests with those who promote urban sprawl, great highway and irrigation projects, and other intensive, competing, land and water uses.

The well-titled contents of the book indicate where most desired information can be found: "Preface; Chapter 1, the Importance of Recreation; 2, Relationship of the Outdoors to Recreational Needs; 3, Development of Recreational Interest in the Outdoors; 4, Recreation in State Parks of the United States; 5, Outdoor Recreation in National Park Service Areas; 6, The National Forests as Outdoor Recreational Areas; 7, Economic Value of Recreational Lands; 8, Administration and Management of Recreational Lands; 9, Important Recreational Facilities and Services; 10, Principal Wild Land Recreational Areas in Other Parts of the World; Index." The index shows that wildlife areas and uses are briefly covered in Chapter 3.

Brockman outlines the changing philosophy of the United States in respect to land ownership. From a nation which believed that eventually all public lands would become privately owned, we have changed to one which fondly and even fiercely has established reservations for public recreation. For those who think inflexibly, approval of public reservations contrasts strangely with our equally vehement approval of each man owning his home. But here is the record, extending from the Great Ponds (public-use) Act of 1641, through the Hot Springs (Arkansas) Reservation of 1832, New York City's Central Park of 1853, the Yosemite Grant of 1864, and the first national park (Yellowstone) in 1872 on to current plans to acquire needed seashores and other recreational reservations. Dates and events within this record of public-land dedication often serve as valuable precedents for wildlife managers. Those who relish statistics find a generous supply.

Professor Brockman learned many of the details he presents while Park Naturalist for Mount Rainier and Yosemite National Parks and, later, as Professor of Forestry at the University of Washington. There he teaches, among other subjects, recreational land use.

The book does not set high standards in writing and editing. Meaningless idioms of kinds which members of the Wildlife Society properly have challenged during recent years are common. However, it is pedantic rather than ungrammatical. Although authors of wildlife papers will recognize shortcomings they strive to avoid, the book is readable, scholarly, and informative. Its relatively high price, for a book with scant volume, may keep it out of many private libraries, but certainly it should be available where wildlife men work.

The reader finds few theories analyzed. The frontiers of outdoor recreational activities—which inherently will long remain nebulous—are indicated primarily by a brief analysis of possible research projects. Instead, this pioneer writing depicts mostly what is and has been. But, amid the uncertainties of any pioneering venture, such pragmatism is understandable. Many will be grateful that explorations in this newest and least definite resource-management activity have at last been charted.—J. V. K. WAGAR, Department of Forest Recreation and Wildlife Conservation, Colorado State University, Fort Collins, Colorado.

Spiders, Scorpions, Centipedes and Mites. By J. L. Cloudsley-Thompson. The Pergamon Press, New York (London, Paris, Los Angeles). 1958. 228 pp., 40 figs. + 17 plates. $9.00.

The subtitle, "The Ecology and Natural History of Woodlice, 'Myriapods,' and Arachnids" much more accurately describes the contents of this book. The eleven chapters are entitled "Woodlice," "Millipedes," "Centipedes," "Other 'Myriapods,'" "Scorpions," "Solifugae," "False Scorpions," "Whip-scorpions and Others," "Harvest-spiders," "Spiders," and "Mites and Ticks." Thus, the major groups of terrestrial arthropods, other than insects (excluding also the Collembola, which the author does not consider insects, and the Onychophora) are covered. An "Introduction" and an "Epilogue" stress the ecological approach and point out how the terrestrial arthropods have become adapted to land conditions. A stated objective is to present an introductory guide to these relatively neglected arthropods (relatively, that is, in comparison with the insects and aquatic crustaceans) and to attempt to stimulate interest in them by indicating "some of the innumerable problems awaiting elucidation."

The treatment is, within limits, quite uniform. Typical subheadings within a chapter are "Classification and Distribution," "General Behavior," "Food and Feeding Habits," "Enemies," and "Reproduction and Life Cycle." Each chapter is followed by a "Bibliography," divided into two sections, "Identification" and "Biology." Consequently, though this book will not serve the purpose of identification, it will provide references to which the student may turn for that purpose. A "General Bibliography" (22 titles) is appended. The author's concept of classification is indicated in a classificatory index which places all species mentioned to family, order and class (sometimes other categories are included); this is followed by an indexed glossary (seven pages) and a general index.

The book makes interesting reading, yet with an economy of words. It is not unnecessarily technical; the intelligent reader should be able to understand, enjoy, and profit by it, even though he may not

have had any special knowledge of the subject beforehand. It is rich in fact and interspersed with anecdote, for example, the legend that the cardinal spider was so called because of Cardinal Wolsey's particular aversion to that species. It seems to be accurate and up-to-date; the author's greater familiarity with the arachnids of the Old World is evidenced, however, by his statement (p. 72) that in America scorpions extend "to the more southern of the United States" (actually, some occur in Canada). The book serves a real need: a relatively small volume that gives a general account of the terrestrial non-insectan arthropods and that can be used either as a terminal reference on a restricted scale or as a starting point for more extensive study.—MAURICE T. JAMES, Washington State University, Pullman, Washington.

Work Notes on Common Statistical Procedures. By F. R. Hayes and D. Pelluet. Scholar's Library, New York. 1958. 60pp.

The authors offer worked examples showing how to perform the calculations with which, in their experience, a student majoring in biological science should be familiar. The statistical tests illustrated are kept to a minimum, though for some reason the large-sample-theory confidence limits and test for significance of differences are discussed separately from the similar small-sample procedures. There is a major section on the chi-square test, a chapter on regression, correlation, and transformations, and the last chapter covers simple procedures useful when working with radioactive tracers. There are several brief abstracts from standard tables, and an interesting graphical summary of normal curve probabilities (p. 12). The ring binding was a happy notion, though the typography is poor.

This is an attempted response to that most common request of biologists, for explicit directions on calculating statistics and freedom from "theoretical" aspects. An examination of this not altogether successful attempt will illustrate why it is so hard to meet this request, for even here over half the brief text is devoted to discussing why and when, as well as how, calculations should be performed; for understanding is the real need of most biologists, not calculating proficiency.

A kind of free-wheeling subjective type of explanation is offered here. Any claim to unique usefulness depends upon this approach being more useful than the more formal discussions already available. Intelligible elementary discussions are needed, but I think that the beginner will find this book too vague on the very points where he will want help, while the person of a little more experience will find the careless phrasing confusing or questionable. Anyone who already knows what the authors are trying to say can follow the discussion and sense that while quite often inexact, statements are rarely in error, at least in intent and within context. As examples the following definitions are chosen from the first chapter:

(p. 1) "t = mean divided by its own standard error = $\frac{M}{\sigma_M}$."

(p. 2) "Degree of freedom: Where n-1, n-2 etc. is used instead of n. The number of degrees of freedom is what is left after 1, 2 etc. has been subtracted from n."

(p. 3) "Poisson series: Set of measurements whose calculation can be simplified as has been done in the section on Geiger counting, which is an example of such a series."

There is a serious fallacy in the discussion of one example (pp. 45–49) where the chi-square test is illustrated in an otherwise correct fashion. Four samples of fish from the same waters are compared, each represented in five age classes. The lack of statistically significant differences is said to demonstrate that the samples are adequate to represent the population. Unhappily, the smaller the sample sizes here, the less will be the likelihood of detecting any differences which may be present. Therefore very small samples would be almost sure to be termed "adequate."

It is doubtful that this book will be extremely helpful to the beginner, and the authors wrote it for beginners only.—DON W. HAYNE, Patuxent Research Refuge, Laurel, Maryland.

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